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The effects of various rates of presentation were studied in combination with massed and spaced, concurrent and nonconcurrent, overt and covert practice modes on film-mediated perceptual performance. Selected values of the independent variables were investigated within a 3x3x2 factorial design, and the experimental treatments were randomly ordered and assigned to 180 graduate students. Three experimental films were prepared, each containing 24 identical performances of the criterion task, an unfamiliar knotted figure. The films were photographed simultaneously at different speeds: normal speed and two slow motion speeds, with verbal instructions programed on tape cartridges. This method allowed examination of three levels of massed-spaced practice and concurrent-nonconcurrent practice. A criterion testing period followed the single practice period to evaluate four dependent variables, involving step analysis scores and the number of criterion tasks completed. Using variance analysis and the Duncan New Multiple Range Test, significant F ratios were calculated for the main effect of rate. The slower rates were found to be more effective. The data suggest that further research may reveal significant differences for concurrent-nonconcurrent practice modes and may demonstrate interactions. (TI)

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THE EFFECTS OF DIFFERENT METHODS OF PRACTICE ON FILM-DIRECTED PERFORMANCES.

Margaret Anne Patricia Montgomery, Principle Investigator
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Indiana University

Bloomington, Indiana

December 1967

The research reported herein was performed pursuant to a grant with the Office of Education, U.S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

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M.A.P.M.

TABLE OF CONTENTS

Page

SUMMARY 1

INTRODUCTION 3

Theory-Oriented, Multivariable Research 4
Experimental Control Through Media Technology 4
Rate of Presentation 4
Massed-Spaced Presentation and Practice 5
Overt and Covert Practice 6
Concurrent Viewing and Practice 7
Knowledge of Results, Prompting and Confirmation . . . 7
Choice of Task and Task Analysis 8
Research Influencing Design of Stimulus Materials . . . 9
Purpose of the Study and the Hypotheses 10

METHOD 11

Experimental Design 11
Subjects 11
Stimulus Materials: The Criterion Task and Criterion Measurement 13
Production Control and Stimulus Materials: Rate of Presentation 16
Stimulus Materials: Taped Instructions 18
Stimulus Materials: Massed-Spaced Practice 20
Stimulus Materials: Concurrent and Nonconcurrent Practice 21
Stimulus Materials: The Cord and the Criterion Testing Device 22
The Laboratory: Equipment and Environmental Control . . 23
The Laboratory: Evaluation and Scoring Procedures . . . 26
Summary of Laboratory Procedure 28

RESULTS 30

Analysis 30
Rate of Presentation Effect 39
Massed-Spaced Practice Mode Effect 43
Concurrent-Nonconcurrent Practice Mode Effect 45
Rate of Presentation by Massed-Spaced Practice Mode Effect 47
Rate of Presentation by Concurrent-Nonconcurrent Practice Mode Effect 49

Page

Massed-Spaced Practice Mode by Concurrent-Nonconcurrent Practice Mode Effect 51
Rate of Presentation by Massed-Spaced Practice Mode by Concurrent-Nonconcurrent Practice Mode Effect . . . 52

CONCLUSIONS AND RECOMMENDATIONS 55

BIBLIOGRAPHY 57

Appendix A: Instructions to Subjects 64
Appendix B: Tape Cartridges for Experimental Treatments. 67
Appendix D: Cell and Marginal Means from Analyses of Variance 69

LIST OF FIGURES

Figure

1. The Criterion Task: Kingfish Knotted Figure . . . 14

2. The Laboratory and Research Equipment. 15

LIST OF TABLES

Table Page

1. Experimental Design 12

2. Summary of the Analysis of Variance. Problem 1: Knots 34

3. Summary of the Analysis of Variance. Problem 2: Tests 35

4. Summary of the Analysis of Variance. Problem 3: Practice Step 36

5. Summary of the Analysis of Variance. Problem 4: Test Step 37

6. Summary of the Duncan New Multiple Range Test 38

7. Marginal Means for Rate of Presentation in Problems 1-4 39

8. Number of Subjects with Knot Score in Problem 1 . . 42

9. Marginal Means for Massed-Spaced Practice Modes in Problems 1-4 44

10. Marginal Means for Concurrent-Nonconcurrent Practice Modes in Problems 1-4 46

11. Cell Means for Interactions 48

SUMMARY

THE EFFECTS OF DIFFERENT METHODS OF PRACTICE ON FILM-DIRECTED PERFORMANCES

The purpose of this study was to investigate the effects of various rates of presentation in combination with massed and spaced, concurrent and nonconcurrent practice modes on film-mediated perceptual motor performance. This was a pioneering investigation into this combination of variables within a factorial design, within a single practice session, and under research conditions that were controlled by the use of media technology.

Three basic films were prepared for the stimulus materials and each contained twenty-four identical performances of the c criterion task. The films differed only in the rate at which they were photographed and subsequently presented - normal speed and two slower motion speeds.

The criterion task was the tying and testing of an unfamiliar knotted figure which involved a series of interrelated steps leading towards a final measurable product.

Three levels of massed-spaced practice were investigated. One third of the subjects watched one criterion task on film and practiced one criterion task alternately throughout the experiment. The second group watched three performances and practiced three tasks alternately. The third group watched six performances and practiced six tasks alternately.

Concurrent and nonconcurrent practice modes were the values of the third variable under investigation. Half of the subjects watched the performance and then practiced without visual stimuli. The verbal instructions were programmed on tape cartridges.

The eighteen experimental treatments were randomly ordered and assigned to one hundred and eighty men and women graduate students in education at Indiana University. The subjects were tested individually within groups of five in an air-conditioned laboratory which was set up like a small portable language laboratory.

The practice period was followed by a criterion testing period and four dependent variables were investigated. Scores were given for the number of criterion tasks completed and step analysis scores were given.

The experimental data was analyzed by the use of four analyses of variance and the Duncan new multiple range test for the significant differences between means. Significant F ratios at the .01 level were found for the main effect of rates of presentation in all of the experimental problems. Slower rates were more effective. No significant difference was found between massed-spaced practice modes. Experimental evidence in some of the problems indicated that concurrent modes may be more effective than nonconcurrent modes. The possibility of interactions being found in future research was suggested. The selected scale of measurement and choice of dependent variable to be examined appeared to have influenced the amount of significant difference found.

This study can serve to generate further research and many related follow-up studies were suggested and described. The development of an integrated body of evidence will lead towards more useful practices in the instructional process involving perceptual motor learning in such diverse areas as the performing arts, special education for the handicapped, athletics, vocational education and industry. Such research may influence educational practice as well as provide insight into how complex perceptual motor skills are learned and how conditions of learning may influence perception and personality.

Margaret Anne Patricia Montgomery

INTRODUCTION

Teachers in the area of perceptual motor learning are confronted with two important tasks. They must present demonstrations of the motor skills to be learned by their students and these demonstrations must contain all of the crucial cues involved in each skill. Such demonstrations serve as models for the students and influence their performance.

The challenge to the teacher does not end here, however. The teacher must carefully set the conditions for learning and vary them according to the particular situation and the problems of students, individually and collectively. Once the perceptual motor skill has been analyzed into its component parts, the teacher must make decisions on how this demonstration will be presented to the students and how the students will practice.

The teaching and performing experiences of the experimenter prompted this investigation. Rate of presentation appeared to have an effect on the motor performance of the experimenter's students but this factor needed study under controlled conditions and in relation to other factors such as practice. The results of this study could reveal the effects of varying the conditions of learning and influence the ways in which perceptual motor skills are presented and practiced.

Glaser (1965) stresses the importance of bridging the critical gap between basic psychological research and teaching practices, thus developing a better defined area of educational research to serve as the link to translate research findings into useful practices. Glaser (1965), Fleishman (1965), and Lumsdaine (1965) are concerned with education and training in the instructional process and the role of instructional technology in industry, the military and in education. They have investigated many areas of learning and one of the emphasized areas has been motor learning. Glaser feels that specific training research can provide results that will have useful implications for psychological research as well as educational practice.

Cratty (1964) shows similar concern and has analyzed most of the important research in human movement behavior. He notes the recent increase in these research studies and the application of the results to such diverse areas as athletics, fine arts, skills for the physically handicapped, technical skills in industry and education, rhythmical activities such as dance, and the skills involved in the integration of man-machine systems. He points out that research in human movement behavior may influence educational practice and even more important, may provide insight into how complex perceptual motor skills are learned.

Theory-Oriented, Multivariable Research

Many investigators stress the importance of theory-oriented film research. Black (1965); Carpenter (1962); Lumsdaine (1964); Smith and Van Ormer (1949) emphasize theoretically-oriented variables rather than gross characteristics of instructional media, thus offering a sounder basis for generalization of results. Lumsdaine discusses the strengths and weaknesses of research studies which involve variation of a single factor and those which involve multivariable experimentation. He concludes that the latter type of research, if kept relatively simple in design, will probably result in broader and more useful generalizations than the former type. He feels that the weakness of the single factor investigation lies in the researcher's probable neglect of possible interaction which could lead to confounded results. The literature suggests the importance of controlled study of the effects of various rates of presentation and practice on perceptual motor performance. The effect of various rates of presentation might be influenced by the kind of practice modes used and therefore a multivariable research design investigating these various factors might yield fruitful results.

Experimental Control Through Media Technology

A lack of controlled presentation of stimulus materials is readily apparent in research in motor learning. Live demonstrations differ even when performed by the same individual expert. This is particularly true when the demonstrator performs at different speeds or rates of presentation. Lumsdaine (1964) discusses the importance of controlled presentation of stimulus materials and he emphasizes the advantages of filmed stimulus materials which can then be repeated ad infinitum in practice situations and test situations. Controlled manipulation of variables such as rates of presentation and repetition is more assured through the unique advantage of having captured a criterion performance permanently on film. Through the use of media technology an expert performance on film can serve as the stimulus material for a variety of experimental conditions and rate of presentation can be manipulated by the use of variable speed photography or variable speed projectors.

Rate of Presentation

Studies involving rate of presentation in film-mediated perceptual motor learning (Jaspen, 1950; McGuire, 1961 ab; Roshal, 1949, 1961) reveal that slower rates of presentation may positively affect performance because the subjects would have more time to observe and make a response. However, the researchers suggest further controlled research. Results from other studies indicate that other factors may influence the effectiveness of rate of presentation. Vincent, Ash and Greenhill (1949) conclude that when a large amount of information is presented at a rapid rate, interference occurs and subsequently affects performance. Hoban and Van Ormer (1950) feel that the length of the task or the amount of information contained in the stimulus materials could interact with the rate of presentation and affect performance. Thus, the criterion task must be carefully selected for this pioneering study. Representative criterion tasks should be selected from the perceptual motor spectrum and should be examined individually and in groups in future research.

Lumsdaine (1965) feels that the adequacy of the original perception is critical and that many skilled acts may occur too quickly, thus hampering the development of a stable perceptual pattern. He urges the use of the unique advantages of the slow-motion capabilities of motion picture technology to investigate rate of presentation.

Gropper and Kress (1965) investigated forced fast-slow practice rates in programmed instruction for subjects of high and low intelligence. They found that intelligence, rate of presentation and self-paced, fixed-paced practice modes did interact to produce significant differences in performance related to verbal comprehension.

There may be an interesting relationship between the rate of presentation and practice and the research that is being done in compression by Travers (1964) where it has been found that speeds in verbal presentation affect comprehension and performance. Humans tend to edit that which is presented to them verbally and visually and Travers indicates that perhaps humans could comprehend at faster rates of presentation depending on the clarity of the message. This approach may contrast with that of the previously mentioned researchers who have suggested the need for slower rates of presentation.

Massed-Spaced Presentation and Practice

Cratty (1964) presents a summary of the research in motor learning. He feels that an exhaustive search of the literature reveals that the question of whether massed or spaced practice is more effective in motor learning remains largely unanswered. He urges further research in both fine and gross motor learning and particularly advocates research concerning massed-spaced practice modes within a single practice session. Cratty reviews the research on massed and spaced practice in relation to long-term retention and he concludes that the very little research that has been done yields conflicting results. When an experiment consists of more than one practice session, it is difficult to exercise control over the time when the subjects are not in the experimental setting. Once research has been conducted on subjects involved in a single practice session, the investigation can be extended to practice sessions of varying lengths and number.

Hilgard and Marquis (1961) examined pursuit-motor performance and found that the massing of practice within a single session proved initially more effective and that the spacing of trials in a single session became more effective later in the learning process. This agrees with Mednick's (1965) review of research on this topic. He advocates massed practice when the tasks are relatively short and not too difficult because there is less chance for work decrement and inter-trial forgetting. Cratty points out the importance of considering the nature of the task, the length of the retention period and the amount of original learning. He feels that research reveals that the internal consistency of the task is a most important variable and that if a task is short, although complex, it should be practiced as a whole. This agrees with the Maccoby and Sheffield (1958, 1961) conclusions when they point out that whole task practice is more effective when the subjects are required to perform the task later without instructional support.

Cratty feels that certain generalizations can be made on the basis of existing research: (1) The amount of spacing of practice seems related to the type of task and the stage of learning reached. (2) Initial massing of practice appears to be most effective for acquiring a base from which to proceed. He points out that some research indicates that those tasks that require visual-motor coordination seem most favorably affected by spacing practice while those tasks that are largely motor seem most favorably affected by massed practice. The perceptual motor skill that has been selected as the criterion task in this investigation requires visual-motor coordination and therefore the spacing practice should prove more effective. On the other hand, the complex task is unknown to the subjects at the beginning of the experiment and so possibly initial massing of practice might be more effective.

Cook (1960) feels that his survey of research reveals that audiences need more repetition of the task than they are usually given. He feels that designers of filmed stimulus materials are so familiar with the task that they tend to underestimate the viewing and practice needs of the audience in order for many of them to reach the level of a criterion performance. Pilot studies will yield data that will enable the determination of how often the criterion task must be repeated in experimental investigations.

Overt and Covert Practice

Lumsdaine (1965) suggests that early forced overt response may lead the subjects into making a response before they are ready perhaps causing a stressful situation and, in addition, causing a practice of errors. He feels that research evidence weighs in favor of the active response and practice but he indicates that such variables as the nature of the task, rate of presentation and the amount of practice time influences the results and must be more thoroughly investigated. Black (1965) examined the research and also believes this may be the case. Hulett (1966) points out the importance of covert rehearsal in his symbolic interactionist model of human communication and he feels that it is here that an individual interprets the motivating stimulus input pattern and organizes his response.

Hovland, Lumsdaine and Sheffield (1949) report that differences between covert and overt practice modes are lessened when a post-test situation is announced to the subjects before the practice trials. However, Michael and Maccoby (1961) report that practice appears to be the key factor and that the overt response appears to be favored for verbal material.

When Michael and Maccoby compared overt versus covert responding to the same set of questions and when both groups had the same length of time to respond, they found no difference between the two groups. This coincides with results of studies by Cook and Spitzer (1960) and Goldbeck (1960). Holland (1960) suggests that the relevance of the responses and cues influences the need for and effectiveness of overt patterns of responses. McGuire (1955 b, 1961 a) reports on studies involving rates of presentation and overt-covert practice modes in the naming of mechanical parts. Rate of presentation was varied during the instructional trials but not during the practice trials. There was no significant difference between the overt and covert groups at the slower rate of presentation but the covert group was significantly better than the overt group at the faster rate of presentation. The overt group was inferior in performance to a non-practice group at the faster rate.

Concurrent Viewing and Practice

Studies have been designed in which the filmed stimulus materials have been presented and then followed by practice (Harby, 1952; Nelson, 1958). Thus, there is an interval between the presentation of a sequence of motor stimuli and the opportunity for the subjects to practice what they have observed. This is in contrast to studies (Jaspen, 1950; McGuire, 1955 abc, 1961 abc; Rimland, 1955; Roshal, 1949) where subjects could practice while they viewed the stimulus materials. Results indicate that concurrent practice may be more difficult at the faster rate of presentation. The researchers suggested the need for further controlled investigation.

Knowledge of Results, Prompting and Confirmation

Lumsdaine (1965) reviews the research and concludes that knowledge of results after covert or overt practice has a positive effect on performance. However, he points out the ambiguity of knowledge of results in that such knowledge may be considered an additional, implicit trial. The importance of immediate and specific knowledge of results rather than a right-wrong partial knowledge of results is stressed.

Cook (1958), Cook and Spitzer (1960) and Irion and Briggs (1957) show the superiority of the prompting procedure over the right-wrong confirmation in paired associate and serial learning. Cook reports the superiority of partial prompting in paired associate materials. In an investigation of concurrent practice and viewing, the film stimulus materials could serve as a prompt or partial prompt. The quality of task performance could be assessed immediately in terms of the criterion measuring standard that would appear on the filmed stimulus materials and against which the subject would test his criterion tasks.

Choice of Task and Task Analysis

Glaser (1965), Gagné and Paradise (1961) and Stolurow (1961) emphasize the importance of specifying objectives and task analysis for the design of research and instruction. Such action clarifies the terminal behavior required and enables the researchers to design and revise stimulus materials that will guide subjects towards the desired terminal behavior. Previous researchers have selected knot-tying as the motor skill to use in their investigation of motor learning (Jaspen, 1950; Rimland, 1955; Roshal, 1949). This serial task is within the perceptual motor realm and involves a sequence of interrelated steps leading towards a criterion terminal conclusion. A trace is available for the entire performance, thus enabling the evaluation of performance at any point during the task. The final product may easily be assessed in terms of quality.

Much depends on the nature and length of the task as to whether or not it should be broken down into small sub-tasks involving short practice units (Lumsdaine, 1965). Research by Maccoby and Sheffield (1958, 1961) reveals that the use of short sub-task practice segments may produce more effective performance during the training period but may result in a decrement in performance when subjects are tested on the whole task without instructional support.

Margolius, Maccoby and Sheffield (1965,1961) report that if a task appears to be inherently well-organized, the practice of the natural unit will probably be more effective than practice of artificially designed stimulus materials. This coincides with Emeson and Wulff's (1957) results that indicate unstructured self-study and practice by subjects is more effective than forced study and practice of ineffectively cued and organized stimulus materials. It appears that the presentation of the integrated, whole motor task and similar practice—if the task is relatively short—would be more effective than presenting subjective, artificially organized and cued film stimulus materials for viewing and practice. A choice of the latter procedure merits specific and exhaustive research because there are so many subjective aspects to the problem.

Mednick (1965) has surveyed the research on serial verbal learning which reveals that the items at the beginning and end of a serial task are easier to learn than those items in the middle. Cratty (1963) reports that his research indicates that this appears to be the case in human locomotor learning. Thus, it might seem that a relatively shorter task could be practiced and viewed as a whole, if it is an integrated whole, more effectively than a longer task containing a longer mid-section. This indicates the necessity of repeating experiments over a variety of similar motor tasks before useful generalizations could be made.

Research Influencing Design of Stimulus Materials

The research by Jaspen (1950) and Roshal (1949, 1961) reveals the importance of presenting the task from the learner's point of view, i.e. the subjective camera angle of zero degrees.

Lumsdaine (1965) reviews the research on color film versus black and white and no significant difference is the common result. Lumsdaine and others feel that future research will show that appropriate use of color cues will aid discrimination. However, inappropriate use could confuse the subject and interfere with learning. Jaspen and Roshal stress the importance of lifelikeness and realism in the presentation of the task. The experimental films will be in color in order to show the lifelike contrast of the colored stimulus materials and enhance the depth dimension.

Kishler indicates in an inconclusive study (1950) that there may be a prestige factor involved in a film where the audience can identify with a film performer. An expert could thus be used for the filmed demonstration of the motor skill and the subjects then be informed simply that the performer is an expert. However, this decision would be influenced by the choice of criterion task and experimental procedure.

Cratty (1965) reviews the major theories and research studies on reminiscence and these studies have conflicting results. Cratty feels that it is very hard to control what the subjects do during these rest intervals and this may partly account for the conflicting results. Perhaps this is the reason that Cratty encourages research into single practice sessions where rest periods are not so vital.

Gropper (1965) describes his research studies that appear to demonstrate that concepts may be taught through the exclusive use of pictures and this could be only one of the reasons that helps to justify the use of a silent film in research into perceptual motor learning. Knowlton (1966) would advocate the use of a silent film in research to avoid the confounding of the audio and visual stimulus variables. McGuire (1955 a, 1961 b) found that an accompanying narrative aided performance. Knowlton would suggest that it is difficult to decide whether the accompanying verbalization is irrelevant in content or just not needed. The motion picture is primarily a visual medium and an investigation involving the use of a silent film might be the more effective starting point with an investigation of complementary narration deemed an important topic for future research. However, taped verbal instructions could accompany the presentation of the filmed stimulus materials. These instructions would cover the procedure for practice only.

Roshal's study (1949) indicates the importance of using motion pictures for presentation of motor tasks. He indicates that many motor skills contain movements that cannot adequately be presented by still pictures.

Purpose of the Study and the Hypotheses

This study will investigate the effects of selected rates of presentation of filmed stimulus materials on the motor performance of subjects who are engaged in selected levels of massed-spaced and concurrent-nonconcurrent practice modes. The hypotheses are as follows:

1. The rate of presentation of filmed stimulus materials significantly affects motor performance. The medium rate of presentation will be significantly better than the slowest or the fastest rates.
2. The massed and spaced practice modes significantly affect motor performance. The medium massed mode will be significantly better than the spaced or massed modes.
3. The concurrent and nonconcurrent practice modes significantly affect motor performance. The concurrent practice mode will be significantly better than the nonconcurrent mode.
4. There is no interaction between rate of presentation and massed-spaced practice modes which significantly affects motor performance.
5. There is no interaction between rate of presentation and the concurrent-nonconcurrent practice modes which significantly affects motor performance.
6. There is no interaction between massed-spaced and concurrent-nonconcurrent practice modes which significantly affects motor performance.
7. There is no interaction among massed-spaced, the concurrent-nonconcurrent practice modes and rate of presentation which significantly affects motor performance.

METHOD

The purpose of this study was to investigate the relationship of three independent variables and their effect on perceptual motor performance: rate of presentation, massed-spaced practice modes, and concurrent-nonconcurrent practice modes. This problem in research resulted in the development by the experimenter of a research laboratory containing appropriate research equipment and stimulus materials. The experimental procedures were undertaken with the objective of testing the hypotheses under conditions that would appropriately control undesired variability and with experimental error at a minimum.

Experimental Design

Table 1 presents the basic experimental design that was used, a 3 x 3 x 2 factorial design. Each subject was assigned to one experimental condition in which he viewed and practiced the filmed stimulus materials within a single practice session. This practice session was followed by a testing period. The dependent variable was the subjects' performance of the criterion task. The score was based on the number of accurate criterion tasks that were performed within a specified testing period. Step analysis scores were recorded during the practice and testing periods.

Subjects

One-hundred-eighty men and women subjects participated in the experiment on a volunteer basis. All of the subjects were enrolled in graduate intersession courses in the School of Education at Indiana University. There were men and women and their age range was 20 through 55 years.

Intersession courses lasted 13 days and they met all morning daily except on Sunday. Consequently, the subjects were available for testing sessions that were scheduled every afternoon. Many of the subjects commuted to Bloomington daily and every effort was made to schedule all subjects at a convenient time and to give all students an opportunity to be in the experiment. Subjects were told that they would receive a copy of the experimental abstract later in the summer which would explain the experiment and their part in it. The students volunteered readily and the total number of subjects was obtained without difficulty.

The subjects were tested in groups of five. Each experimental condition contained 10 subjects. The 18 experimental conditions were randomly selected and ordered two separate times and the testing sessions were conducted in that order throughout intersession. Half of the sub-

TABLE 1. EXPERIMENTAL DESIGN

		Rate of presentation		
		Slowest	Medium	Fastest
Massed—spaced practice modes	Concurrent and nonconcurrent practice modes			
Spaced	Concurrent*	1	7	13
(Watch one film knot, then practice one)	Nonconcurrent*	2	8	14
Medium massed	Concurrent	3	9	15
(Watch three film knots, then practice three)	Nonconcurrent	4	10	16
Massed	Concurrent	5	11	17
(Watch six film knots, then practice six)	Nonconcurrent	6	12	18

*Concurrent practice mode: practice with visual stimulus; tie knot during practice interval with simultaneous viewing of film performance

*Nonconcurrent practice mode: practice without visual stimulus; tie knot during practice interval without any visual stimulus jects in each experimental condition were tested during the first half of the experiment and the remaining five subjects in each condition were tested during the last half of the experiment. Replication in the experiment was carried out in two ways: independent testing within groups of five subjects for each condition and testing of half of the subjects of each experimental condition on two separate occasions. In addition, each subject randomly selected his testing position in the laboratory.

The randomization procedure for obtaining subjects and ordering and assigning treatments was carefully planned within the limitations of intersession. The procedure for obtaining subjects had to be the same for all and the procedure adopted was as randomized as possible under the circumstances. Hays (1965) points out that experimental designs in which more than one variable is introduced and where other factors contributing to variance are randomized or systematically controlled can strengthen the randomization procedure and lead towards greater experimental precision. In this study it was assumed that such controls should have helped to lead towards significant differences that were more likely a result of differences in treatments rather than unplanned for differences among the subjects themselves.

Stimulus Materials: The Criterion Task and Criterion Measurment

An expert performer was filmed as she tied an Asian knotted figure called the Kingfish. The criterion task is presented in Figure 1. This knotted figure involves a sequence of fine motor manipulations that are interrelated and result in an easily observable and measurable product of performance. The Kingfish was selected because the subjects were unlikely to know how to tie it before the experiment. After the experiment all subjects verified that they had not known the knot beforehand. Also, it was selected deliberately because it should not suggest any obvious relationship to such sex-linked activities as sewing, weaving, boy scout and navy knotting. It was deemed important to have a criterion task that was interesting to both sexes. The alert, intent behavior of all the subjects during the experiment and their comments later suggested that both sexes found the task interesting and challenging.

The expert film performer placed the completed knot over a pointer testing device as shown in Figure 2, and tested a correct knot. If the knot has been tied correctly, it releases without tangling when one hand is removed from the knot and the other hand pulls the rope away from the pointing device. If the knot has been incorrectly tied, it will tangle over the pointing device when the hand-releasing action is performed. Consequently, the knot can be easily evaluated in a

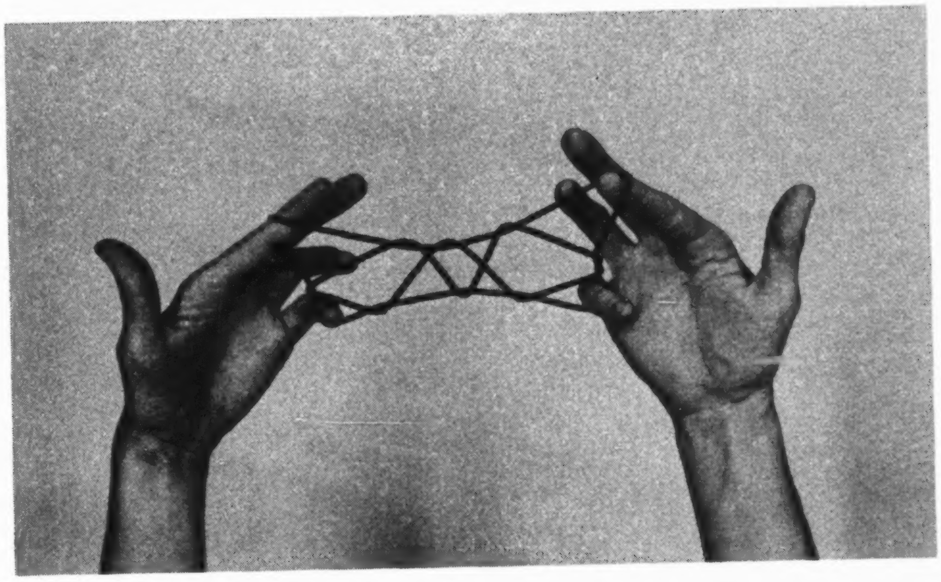
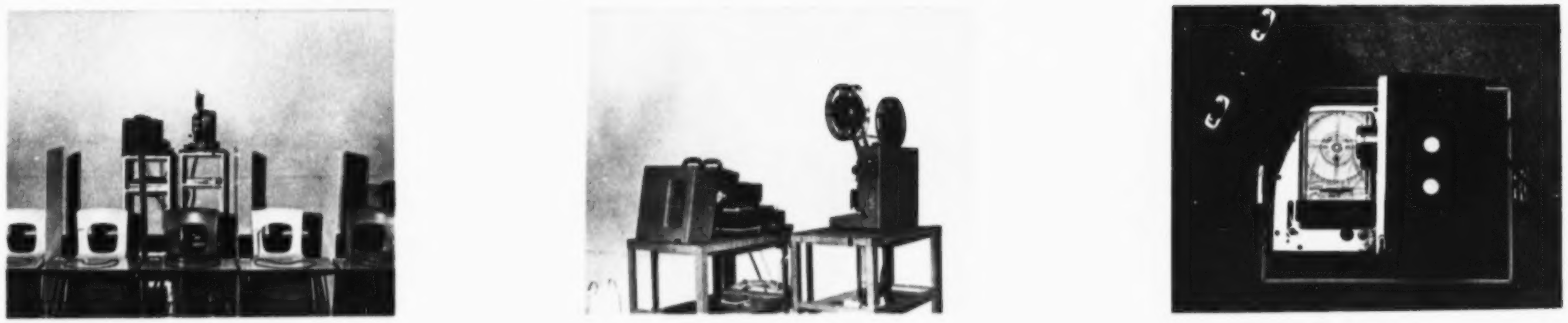


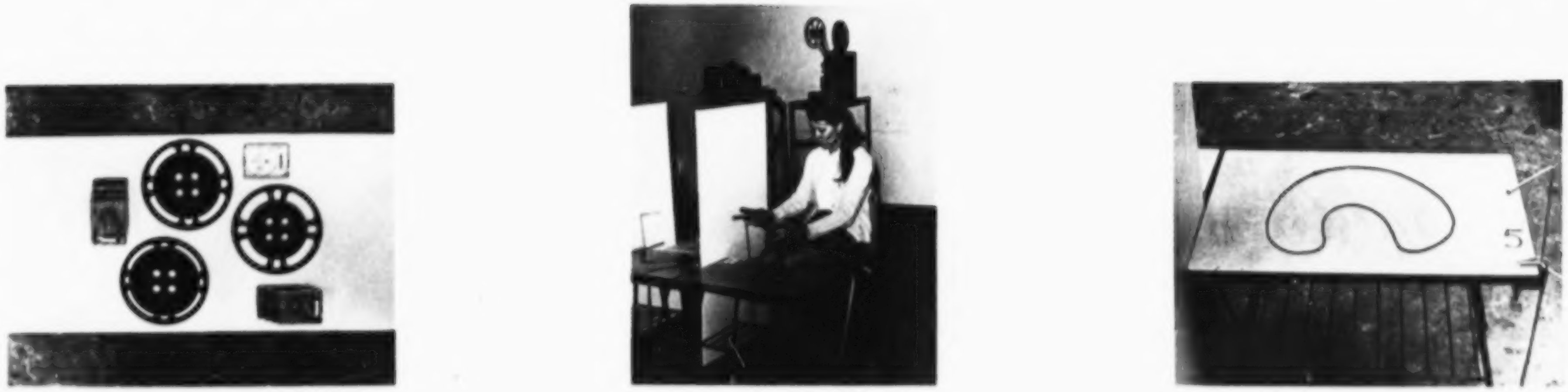
Figure 1. The Criterion Task: Kingfish Knotted Figure



Laboratory Setting

Projection Equipment

Tape Cartridge Player



Stimulus Materials

Testing the Knot

Testing Table and Device

Figure 2. The Laboratory and Research Equipment

binary right-wrong scoring system and immediate knowledge of results is available to the subject and the scorer.

Production Controls and Stimulus Materials:
Rate of Presentation

Three 16 millimeter cameras were mounted side by side on a metal bracket which was then mounted on a tripod. The tripod was placed on a scaffold and the expert performer was photographed from the subjective zero degree angle with the three cameras simultaneously operating at the selected different speeds of 16 frames per second (normal silent speed), 32 frames per second (twice as slow) and 48 frames per second (three times as slow). The three cameras simultaneously recorded nine separate knot-tying performances on 16 millimeter commercial Ektachrome color film.

The film sequence finally chosen was selected on the basis of all-round clarity in presentation of the steps involved in the criterion task. The experimenter and expert performer were certain that the sequence of film they had selected was the better of the two final choices. Their judgment proved correct when they presented the final two choices to a random group of subjects in a pilot study held during the semester before the final experiment was conducted. The subjects missed the critical final cues that were not as well performed in the second best sequence and as a consequence, they tied incomplete knots. The subjects who viewed the chosen sequence of film were able to tie correct knots and none tied the incomplete knot that was so characteristic of the other group. Thus, judgment was corroborated by actual trial of the film with subjects.

Even though an expert may perform a skill many times and each performance may look similar or identical to all of the others, the film analysis of all of the sequences revealed the intra-trial differences. The importance of recording performance with three cameras operating simultaneously cannot be stressed enough if identical stimulus materials except for the speed variable are to be obtained.

The cameras were placed close together on the bracket and from the photographing position up on the scaffold, the angle differences were at a minimum. The performer, experimenter and a film consultant from the Audio-Visual Center were unable to detect angle differences in the final films. The experimenter had a choice between using three adjacent cameras simultaneously shooting the criterion task and using one camera to shoot three performances at the different speeds. The objective was control and to get as nearly identical stimulus materials as possible. Therefore, the three camera technique was selected.

The rates of speed were selected after consultation with experts in photography on the audio-visual faculty. The slowest speed is three times as slow as the normal speed. Three speeds were chosen in this pioneering study with the intention that more speeds could be selected at random for future study if significant differences were found.

The expert performer rehearsed and was photographed many times before the final nine sequences were filmed. Each film was analyzed in terms of crucial cues that must appear on the film. The subjects are restricted to a two-dimensional viewing situation in the experiment and they must be able to see the crucial or critical cues involved in the task. A live performance has a third dimension which enables the viewer to maneuver into a better viewing position. Controlled research demands as identical an experimental environment as possible. Consequently, every effort was made to produce the stimulus materials on film with all of the critical cues available on the three films that were as identical as possible except for the controlled differences in speed.

A pilot study revealed that approximately 30 per cent of the subjects could complete this complex, nine-step task if they could practice 12 knots. The rest of the subjects would range in step analysis scores from zero through eight. Twelve was selected as the number of knots to be physically practiced in the experimental treatments in addition to the number of knots that would be viewed by the subjects.

Each of the three films contained 24 knot-tying segments which were printed from the original chosen sequence of film. This technique ensured that all subjects would view identical knots except for speed. Identical lengths of blank leader were placed at the beginning and end of the three films and between all of the segments. The leader was cut on a frames per second basis to ensure that intervals of time between film segments were the same for all experimental treatments. Pre-experimental tryouts indicated that 10 seconds of blank leader would give sufficient time to the subjects to return to the starting position for the next experimental segment and to listen to the brief taped instructions.

The experimenter edited the 24 identical segments for each film and made certain that they all started and finished on the same frame of action relative to the speed of the film. The experimenter took special precautions to make strong splices. A hot splicer was used and the films were checked by the electronic film inspector in the Audio-Visual Center before and during the experiment. It was imperative not to have malfunctions of materials or equipment during the experiment and there were none.

Sixteen millimeter color film was used in order to provide the clearest, most realistic picture possible. Preliminary film was shot in black and white as well as color. Color film was selected because it provided more depth dimension which was so necessary in the transmission of the critical cues involved in this perceptual motor task.

The pilot study provided information which influenced production factors and subsequent experimental procedures. The pilot study revealed which film sequence was better. The use of 16 millimeter loop and reel film was examined within the experimental setting of the pilot study and presentation on reel was much more efficient and less prone to malfunction. Decisions were made on other aspects of the experimental procedure and modifications were made on verbal instructions. The decision was made on the number of criterion tasks to present and have practiced on the basis of the performance of the subjects in the pilot study. It was during this pilot study that the experimenter realized that various parts of the subjects' performance during the actual experiment should be evaluated. The pilot study showed that it was possible to test a group of subjects as individuals simultaneously if language laboratory cubicles were developed and if a 16 millimeter picture were used.

Stimulus Materials: Taped Instructions

The experimental instructions were placed on tape cartridges so that all of the subjects would receive as identical instructions as possible. The cartridges containing the introductory and testing instructions were played to all subjects. The cartridges containing the instructions for the various experimental treatments were as identical as possible but had to contain some differences that directly related to each unique experimental condition. A more detailed description of the contents of the taped cartridges is contained in Appendix A and Appendix B.

Tape cartridge recording and playing equipment was obtained on loan from the Audion Corporation. This unit is attached to, and synchronized with, a Technicolor 8 millimeter cartridge projector. The complete unit could be used on an auto-tutorial, auto-testing basis and provide auditory and visual stimuli. It was used only for auditory stimuli in this research study. The 16 millimeter film was chosen to transmit the visual stimuli because it could provide a larger, clearer picture of the complex criterion task. Photographs of the equipment appear in Figure 2.

The tape cartridges provided many advantages that led towards more controlled laboratory procedures. There was no threading problem and because the tape was not physically handled, it was less prone to malfunctioning during the experiment. There were no malfunctions during the experiment.

This particular tape unit permitted the use of aluminum sensing tape which could be placed on the auditory tape to stop the playback at specified points. This greatly reduced the amount of tape that was necessary for the treatment tapes. One cartridge could be programmed for use across the three values of the rate variable. The cartridge would be prepared for use in the normal speed condition. It could then be used in the comparable treatment within the two slower values. Consequently, six tape cartridges were used for the 18 treatments.

Each tape cartridge contained approximately two minutes of tape. Sensing tape was placed at specified points throughout the tape. The tape machine would transmit the appropriate instructions and then automatically stop at the sensing tape point. The experimenter would punch the starting switch the moment the yellow blank leader appeared on the screen and the next set of instructions would automatically be heard. Basically there were two sets of brief instructions on each tape. The first set dealt with the viewing instructions and the second set dealt with the practicing instructions. The treatment tapes were programmed for the two sets of instructions with stopping points and then were ready for use across the rate conditions. The instructions on each tape cartridge were thus played and replayed a specified number of times throughout the treatments.

In summary, the tape cartridges had definite advantages in this experimental study. The taped instructions which then could be repeated throughout the treatment added to the control of the experimental procedure and provided economy in the amount of tape needed for use. The sensing tape and stopping technique permitted the tapes to be used across rate treatments, again providing control in the presentation of stimuli and economy of tape.

The tape cartridges were less likely to malfunction during the experiment. Also, no matter how the experimenter might vary in degree of fatigue or excitement, if she was able to push a button upon the cue from the film, the experiment proceeded under experimental control. The programmed film and tapes provided interrelated cues and the experimenter simply pushed one tape or projector switch upon a predetermined auditory or visual cue. There was no malfunction, human or machine, in the presentation of stimuli throughout the experiment.

The treatment tapes were used only to provide instructions on when to watch the film and when to practice the criterion task. While the film was on the screen, there were no auditory cues.

It was more economical to use cartridge tapes than conventional tape reels or sound film. However, the most important factor underlying their selection was that their use led to more controlled stimulus materials and consequently to greater experimental precision.

The experimenter recorded her own voice for the taped instructions. The taping had to be done when the local FM radio station was off the air in order to obtain no interference. The recording levels were the same for all tapes and the recording techniques were as identical as possible, i.e. placement of microphone, distance of experimenter from microphone, etc. Immediate playback and comparison with other tapes revealed any discrepancies to the experimenter and research assistant. Recording continued until they were satisfied that the tapes were as identical as possible.

The tapes were played during the pilot study and the subjects' performance revealed where tape changes and modifications would have to be made. The tapes were re-recorded with the modifications.

An 8 ohm loudspeaker was attached to the external speaker plug of the tape machine and this provided better sound for the subjects during the experiment. A low hum that came from the machine's motor was not heard as a consequence.

Stimulus Materials: Massed-Spaced Practice

Cratty (1964) and Lumsdaine (1964) have stressed the importance of conducting research within single practice sessions. Cratty in particular advocates research into massed-spaced practice modes within single practice sessions. Three values of this variable were selected for study. All of these resultant experimental conditions involved the subjects in first viewing the same expert performance of the one knot a specified number of times and then practicing this criterion task a specified number of times. The three different experimental conditions were as follows:

1. Watch one knot-tying performance on film; then tie one knot in practice. This was done alternately throughout the presentation of the film during the practice period. (spaced)
2. Watch three knot-tying performances on film; then tie three knots in practice. This was done alternately throughout the presentation of the film during the practice peirod, (medium massed)
3. Watch six knot-tying performances on film; then tie six knots in practice. This was done alternately throughout the presentation of the film during the practice period. (massed)

All subjects had an opportunity to tie 12 knots during the practice period. However, the number of knots they would have tied consecutively at any one time during the practice period depended on their experimental condition.

The taped verbal instructions controlled the way in which the subjects viewed the film and practiced. Once the film started, it played continuously through the identical film segments and blank leader segments. The programmed tape cartridges gave the instructions when to watch and when to practice during the projection of the yellow blank leader film segments.

Stimulus Materials: Concurrent and Nonconcurrent Practice

Each of the massed-spaced practice modes was subdivided into concurrent and nonconcurrent practice modes. In the concurrent practice conditions the subjects watched the film knot first and then watched the film knot while tying their own knot. In the nonconcurrent practice condition, the subjects watched the film knot and then tied their own knot without visual filmed stimuli. The effect on performance of overt practice with and without an accompanying visual stimuli was under investigation.

The subjects in the concurrent practice conditions saw 12 film-knot segments. In addition, they practiced while simultaneously viewing 12 knots. Thus, they viewed 24 knots and practiced 12 knots. How they viewed and practiced was controlled by the verbal instructions on the tape cartridges. These were programmed according to the experimental conditions involving the values of the independent variables.

The subjects in the nonconcurrent practice conditions saw 12 film-knot segments. In addition they practiced 12 knots without the accompanying visual film stimuli.

Once the film stimulus materials began projecting during the experimental treatments, one knot-tying film segment appeared after another, with 10 seconds of yellow blank-leader segments between all of the film performances. The 24 filmed performances appeared on the screen without interruption during the concurrent experimental conditions. The viewing and practice were controlled by the programmed taped instructions and by the rate of presentation specified for the particular experimental treatment.

The nonconcurrent experimental treatments were similarly controlled. In addition, there was one critical treatment control for the nonconcurrent experimental conditions only. The subjects in these conditions has to practice without seeing the visual filmed stimulus materials. During the time segments when these subjects were tying the knot, the projection lamp was turned off. When the yellow

Blank leader arrived at the film gate, the light was turned off and the tape switch was turned on for the next instructions. The technical procedure was the same for all concurrent and nonconcurrent conditions except for this use of the projection lamp as an experimental control.

The projector continued to run throughout the nonconcurrent experimental conditions for three important reasons. First, the motor noise was held constant for all subjects and throughout each entire practice session. Second, the film segment moved through the projector and was constantly serving as the experimenter's check on the time allotted to each actual knot-tying practice by the subjects. As long as the film segment was moving through the unlighted projector, the actual knot-tying practice by the subjects continued. As soon as the yellow blank leader approached the film gate, the experimenter moved to the projector and tape cartridge player and got ready to turn on the lamp and tape recorder. In addition, the experimenter timed this interval with a stopwatch. This served as a double check on controlling the time and freed the experimenter to observe the subjects' knot-tying practice at close range.

The third important reason for using this technique is that it saved wear and tear on the films and helped to prevent malfunctions during the experiment. Turning the projector on and off throughout the film presentation would have greatly increased chances of tearing the film. Turning the lamp on and off during the concurrent conditions was a calculated risk and could have resulted in malfunction during the experiment. This procedure appeared to lead to the most controlled presentation even with this risk and so it was adopted for use. There was no malfuction of the lamp in any experimental condition. The lamp was changed once halfway through the experiment.

All of these technical decisions led towards more experimental control and consequently helped to increase experimental precision.

Stimulus Materials: The Cord and the Criterion Testing Device

The criterion task was selected on the basis of its structural characteristics, its unfamilarity characteristic and because it did not appear to favor sex-biased activities such as navy and scout knotting and sewing. The cord had to be selected with comparable care. The decision was made to use a lightweight seine cord, not thread or rope. Cord samples were obtained from cord and fabric companies and finally one was selected for the task. The cord had to be braided to form a loop and many of the sample cords could not be braided. Photographs of the braided loop of cord are presented in Figure 1 and 2.

The expert film performer was a consultant in the preparation of all of the stimulus materials and she braided the cords into loops of various sizes. The pilot study revealed the best size for men and women subjects and this was a loop of 45 inches in length. Smaller loops handicapped the male subjects but men and women subjects handled the 45 inch loop easily.

Trial 8 millimeter color film was shot to obtain the best photographic techniques and also to see which color would be best for the background and for the loop. Test loops were made of various colors. Black was selected by the researcher and consultants as the best color for the cord. The intricate finger actions and cord manipulations showed up best when black cord was used.

The criterion testing device was developed by the experimenter and the research assistant. This device was essentially a pointer over which the completed knot could be placed for evaluation and immediate feedback to scorer and subject. The device needed a pointer, a secure base and it needed to be in a convenient place. The experimenter drew up a design which fulfilled these specifications. The device screwed onto the individual testing table and consequently was stable when the knot was tested. The angle of the pointer was placed diagonally towards the subject to allow easy testing. In addition, an extra projection on the device served as a holder for extra loops of cord for each subject.

Five identical testing devices were made to specifications at a local welding shop. They were painted yellow and served as a contrast with the black cord. Each testing device was placed in an identical position for each subject.

The Laboratory: Equipment and Environmental Control

The experimental laboratory was set up in an air conditioned classroom in the School of Education. The summer months in Indiana can be very hot and humid and it was considered vital to conduct the experiment under optimum and controlled climate conditions in the classroom. The air conditioned classroom became available for use at noon daily throughout the week. The laboratory could be set up for experimental use within 15 minutes and pictures of the laboratory setting appear in Figure 2.

The level of air conditioning was geared for a classroom full of students. The experimenter opened the classroom windows each afternoon to let in the warm outside air and keep the temperature in the low seventies. If this was not done, the temperature would have dropped to the low sixties and performance could have been affected. Sweaters were placed on the back of each chair. If a student put one on, he was instructed to place his arms in the sleeves so he would not have any restrictions on his hand actions.

The lighting level was controlled by adjustments made in the venetian blinds throughout the afternoon. The afternoons and early evenings were bright and sunny throughout intersession and very few adjustments of the blinds had to be made. No testing sessions were conducted after dusk. It was considered important to test groups under common lighting conditions and to set up testing appointments daily within a certain block of time. The subjects in the nonconcurrent treatments had to have enough light to see during the time the projector lamp was turned off and therefore this lighting level was adopted for the entire experiment. The subjects were all involved in the similar academic schedules and the fatigue and tensions that would be associated with the concentrated course work of intersession and the afternoon-early evening block of time was selected for the daily testing sessions.

The appointments were scheduled with intervals between all testing sessions. This procedure helped to prevent the testing subjects from coming in contact with subjects outside the laboratory. All subjects were cautioned not to discuss any aspect of the experiment until they received a copy of the abstract in the mail.

The subjects waited outside the laboratory and the research assistant had them draw for laboratory seats. Then they signed the laboratory record book in the appropriate space and filled in the necessary data about themselves. This provided information on name, address, sex, age, major and current intersession course. This information was listed along side the number of their laboratory position and experimental treatment.

Placement of equipment. The position of the laboratory equipment was marked and all equipment was placed in the same position for all testing sessions. The experimenter and research assistant experimented with the placement of the screen and projector relative to the five laboratory individual testing positions. The viewing of the film performer's complex finger actions was critical. The placement of the research equipment was determined by these actions which were contained in the center of the film frame.

Group testing and experimental control. The experimenter considered testing individual subjects and then decided that the laboratory could be set up to test more subjects at one time, though still retaining the individual testing characteristic. Testing more subjects at one time would not only cut down on the total experimental time but it would help to ensure that the experiment could be completed during intersession. This procedure was successful during the pilot study and the decision proved a wise one. Testing began on the second day of intersession and was completed on the last day of classes. Testing subjects in groups, though still on an individual basis, reduced the number of testing sessions needed and consequently helped to decrease the possibile variability that would result from five times as many testing sessions. This procedure would also decrease the wear and tear on equipment and materials and helped to decrease chances of malfunction.

The experimenter decided to test five subjects per testing session for three reasons. Five subjects appeared to be the maximum number that should be tested together so that the differences in angle and position of viewing could be kept to a minimum. Also, this number could be handled by the two scorers during the testing session. One scorer evaluated three subjects and the other scorer evaluated two subjects and operated the equipment switches. Finally, there would be 10 subjects in each experimental condition. By testing five subjects at a time, half of the subjects in each experimental condition would be tested in the first half of intersession and the remaining subjects in each experimental condition would be tested in the second half. This procedure would strengthen the procedures involved in randomization of subjects and treatments and serve as a check on intersubexperimental reliability.

The laboratory setting was developed for testing five subjects at a time. Various testing tables were considered and finally five identical, low individual tables were obtained. The research assistant and experimenter tried tables of various heights and decided that the lower individual tables were best for working on the criterion task and for attaching the testing device. The individual tables also enabled the placement of styrofoam panels between them, thus creating five portable, language laboratory individual cubicles. This laboratory arrangement is pictured in Figure 2. Five identical lightweight contour chairs were placed at the testing tables. All of the research equipment was easily set up for the experiment and easily and conveniently stored at the end of each testing day.

The styrofoam panels were placed vertically between the testing tables and subjects were unable to see their neighbors performing during the test. The subjects did not communicate with each other in the laboratory until the testing session was over.

Programmed instructions and subjects' questions. Once the subjects entered the laboratory, all of the experimental instructions were given by the tape cartridges. There was a minimum of live communication between the experimenter, research assistant and the subjects. The tape provided time for the subjects to ask questions at a critical point during the testing. Only two subjects asked a question. Fortunately, one subject in the first tested group asked what a subject should do during the test if he did not get the knot during the practice. The experimenter told the group to keep practicing as far as they could go and keep working during the test on trying to get the knot. It was impossible to insert this statement on the cartridge without re-doing the cartridge with the danger of change in tone and emphasis which would then be a source of variance in the instructions. The experimenter decided to make this same statement live at the same question point in each testing session. The statement to keep working on the steps of the knot during the testing session was an important addition. The experimenter had this in the taped instructions but a clearer statement was needed.

The Laboratory: Evaluation and Scoring Procedures

Selection of scorers. The experimenter and film performer were the two persons most familiar with the criterion task and test. The film performer was not only knowledgeable about the task and test, she also was an expert in motor learning and had taught dance and courses in movement on the college level for a number of years. She was the logical choice as the research assistant and scorer in the experiment.

Task analysis and scoring system. The experimenter and research assistant had worked carefully together in the selection and filming of the criterion task and in the development of the laboratory. It was relatively easy for them to set up a scoring system for the testing sessions. They had already analyzed the task into 10 component parts or interrelated steps, including testing the knot. Together they evaluated the steps in the film performance and in pre-experimental subjects' performance to make certain that they agreed on their step scoring system. Their agreement on evaluation of steps and scoring was easily achieved before the experiment began and consequently inter-scorer variability should have been at a minimum. Scores were given for the following sets of behavior:

1. The total number of accurate knots tied during the testing period
2. The total number of accurate knots tied and tested correctly during the testing period
3. The highest step reached in the criterion task during the practice period
4. The highest step reached in the criterion task during the testing period.

The experimenter decided before the small pilot study was conducted that there was a chance that subjects might tie the knot incorrectly and lose the entire score for this mistake. Some subjects might fail to test an accurate knot correctly once or twice; others might fail to test their knot correctly each time, thereby indicating that they had not learned this testing step. The chosen overall scoring system for the criterion test was a binary one. The subject either completed correctly the sequence of steps involved in the task in order to score or he failed to complete the task correctly and scored zero. The introduction of dependent variable one added to the overall analysis. All accurate knots were evaluated in one analysis of variance and these scores could help to differentiate the effectiveness of the various experimental treatments. The results of the two analyses could be compared to see if some subjects were not testing knots correctly and if there were such subjects, had they received similar treatments. The choice of the scale of measurement and what is to be measured greatly influences the experimental findings. It is important to obtain relevant measures that will help to differentiate effectiveness among treatments. Consequently, the experimenter decided to include measures on dependent variable one and not to exclude what might be important experimental data.

The decision to include step analysis scores during the practice and testing periods was made for similar reasons. Dependent variables 1 and 2 would reveal important information on the number of subjects that were successful and to what degree they were successful. However, the data collected under this binary scoring system would reveal nothing about the unsuccessful subjects except how many there were. The experiment was designed to find out the relative effectiveness of the various experimental treatments and the experimenter decided that, if at all possible, step analysis scores could reveal information on whether subjects improved or declined in performance from the practice period to the testing period. In addition, these scores would yield valuable information on all subjects on the comparative effectiveness of the experimental treatments. This information would complement the data gleaned from the binary scoring system.

During the pilot study the scorers found that they could watch the subjects' hand actions from a position at least two feet behind the subjects and if they placed themselves between subjects, they would not have to move distractingly back and forth. The film was projected on the upper half of the screen and the subjects tended to lift their hands up in front of them while tying the knot. This made the hand action easier to see and to evaluate.

The scorers found in the small pilot study that they could easily watch the hand actions of their subjects. Most subjects did not change rapidly throughout the practice and testing periods and many of them would stay at the same step level for more than two trials. Consequently, scorers could begin to judge how far the subject would go on the next knotting trial. If the scorer would miss the knotting trial of one subject because he was involved in evaluating the trial of another subject, the next trial of the missed subject would reveal his progress.

Score books. The scorers prepared scoring record books before the experiment began. Loose scoring sheets that could be easily lost were not used. The records were kept in two notebooks--one for each scorer. The research assistant kept the record book for the first three subjects and the experimenter recorded the performance of subjects in laboratory positions four and five in her notebook. Individual scores and comments were kept in the appropriate spaces and observations concerning the whole experimental group were kept in the appropriate space. Observations on other aspects of the experiment were kept in a convenient space for each testing session. These observations might have been lost unless they were jotted down quickly and organized after the experiment was over.

After the experiment was over, the scores were transferred to scoring sheets that would be sent to the computer research center. No attempt was made to examine or transfer the scores and comments until the experiment was over. The scorers transferred the scores to the scoring sheets for the computer.

Summary of Laboratory Procedure

A summary of the laboratory procedure is presented as follows:

1. The experimental treatments were randomly selected and ordered two separate times, creating two sub-experiments.
2. Subjects volunteered to be in the study and selected a convenient testing time. These testing times were assigned to experimental treatment based on the random selection order. Five subjects were tested in one testing session although each subject was tested individually within the group setting. The five subjects represented half of the subjects from one experimental condition.
3. The subjects waited outside the laboratory and randomly selected their testing position in the laboratory. The subjects then registered themselves in the subject data book.
4. The subjects entered the laboratory and took their designated testing postion. There was no interaction among subjects until the testing session was over.
5. The visual stimulus materials were presented on film and the verbal instructions were presented on tape cartridges. The experimenter controlled the mechanized presentation of stimuli by the simple on-off switches on the apparatus.

6. The experimenter and research assistant served as scorers, each supervising their own assigned testing positions throughout the experiment.

7. Once the taped instructions were started, the experimental testing session continued on to the end without interruption.

8. The visual and auditory stimuli were presented as follows:

a. Instructional tape cartridge 1;

b. Instructional tape cartridge 2;

c. Experimental treatment cartridge and film treatment--first half;

d. Replay instructional tape cartridge 2 and rewind film. Subjects relax and listen;

e. Experimental treatment cartridge and film treatment--second half;

f. Instructional tape cartridge 3 followed by the five minute test. Conclude with the remaining instructions on the tape.

9. The experimenter and research assistant met briefly with the subjects after the test was over and worked informally with those who did not get the completed knot. Usually all of the subjects stayed to discuss and work on the knot. They were told they were free to leave but most of them stayed until all of the group left. The subjects were again cautioned not to discuss any aspect of the experiment with anyone until they received a copy of the abstract. Each one agreed to remain silent.

10. The subjects left the laboratory and the researchers prepared for the next group of subjects. The laboratory was dismantled at the end of each testing day and then set up the following day after the morning class was over.

RESULTS

Analysis

Treatment of the data collected from one hundred and eighty subjects began with the transfer of the data from the scoring sheets. Lined scoring sheets were used to record these data. This procedure helped to prevent errors in the transfer of the scores and in the punching of the computer data cards by skilled card punch operators. The experimenter and research assistant transferred all of the data and checked the punched computer cards.

The computer cards were prepared according to the requirements of an analysis of variance program* which was appropriate for handling the multivariable design of the study. One card was key-punched for each of the one hundred and eighty subjects and each card contained all of the data necessary for the analysis.

Performance measures were taken on four dependent variables and four separate analyses of variance were applied to the data. A model I analysis (Winer, 1962) was judged as being most appropriate because the values of the experimental factors were fixed or selected.

The experimenter wanted to find out the effect of selected values of three factors on perceptual motor performance. The criterion test was the number of accurate knots that a subject could tie and test in a specified time period and this performance was the dependent variable. The experimenter decided on the basis of the results of the small pilot study that it would be important to collect as much relavant data on the performance of the subjects as possible in this pioneering investigation. Such data could prove to be extremely useful in evaluation of the hypotheses. Consequently, measures were taken on three other components of the subjects' performance during the experiment and this resulted in the four dependent variables. They are as follows:

1. The total number of accurate knots tied during the testing period
2. The total number of accurate knots tied and tested correctly during the testing period
3. The highest step reached in the criterion task during the practice period
4. The highest step reached in the criterion task during the testing period.

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*BMD02V--Analysis of Variance for Factorial Design version of May 20, 1964, Health Sciences Computing Facility, UCLA.

The complete results of the four analyses of variance are summarized in Tables 2-5. The cell and marginal means for the four analyses will appear in Appendix C. The three main effects considered were: rate of presentation, massed and spaced practice modes, and concurrent and nonconcurrent practice modes. Four secondary interaction effects were included: rate and massed-spaced practice modes, rate and concurrent-nonconcurrent practice modes, massed-spaced and concurrent-nonconcurrent practice modes and finally, rate and massed-spaced, and concurrent-nonconcurrent practice modes. Edwards (1960), Hays (1965), and Winer (1962) discuss the assumptions that underlie inferences about treatment effects in an analysis of variance in a fixed effects model. They feel that the F test is robust and that even when each population departs from normality, the F test is relatively unaffected. They feel the assumption of homogeneity of variance could be violated without undue risk if the number of cases in each sample is the same. They emphasize the importance of statistical independence among the error components and that no observation should be related to any other observation. The observations made in this experiment were designed to be independent ones.

The F test was considered robust enough to meet the needs of the statistical analysis in this experiment. The .05 level of confidence was selected prior to the experiment. Only those ratios exceeding the appropriate critical F values are reported in the tables. The error term for this fixed effects model was within the replicated mean square and it was used for all of the F tests (Edwards, 1960; McGuigan, 1960; McNemar, 1955; Winer, 1962). It was assumed as a result of the controls set up in this experiment that any experimental error leading to variance was constant over all of the experimental cells.

McNemar (1955) suggests the use of a pooled error term when S^2rbc is tested against S^2w and results in a low F ratio that is not significant at the .05 level. In addition to the chosen error term, a pooled error term was used for Problems 1 and 2 where the overall F ratio was not significant. The results were generally the same when both error terms were used separately in these problems. Only the results involving the use of the chosen error term have been reported unless otherwise mentioned.

Once the results of the analyses of variance were examined, the computer cards were prepared according to the requirements of a Duncan's multiple range test program* which was appropriate for the task of closer inspection of the means and their significant differences.

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*BMD07V--Multiple Range Tests, version of October 12, 1965, Health Sciences Computing Facility, UCLA.

Relevant results are presented in tables that follow and discussion of these results are presented in sections for each hypothesis.

Hays (1965) points out that as the number of comparisons among the means increase, the greater the probability that some significant differences are due to chance alone. Consequently, in multiple comparisons and particularly in post hoc comparisons where Type 2 error is more likely to occur, it is important not to exaggerate the importance of significant mean differences.

Edwards (1960) regards Duncan's multiple range test as being more powerful when the significance of more than two means is involved in the multiple comparisons. Edwards also feels that the multiple comparisons of the means can be made even if the relevant F ratio is not significant but he urges caution on any subsequent observations. McNemar (1955) feels that tests on means can be made safely only when the overall F ratio is significant. Winer (1962) points out that multiple comparisons that are built into the experimental design or suggested by the theoretical framework should be made regardless of how significant the F ratio was. However, he urges extreme caution when unplanned, a posteriori comparisons are made when the overall F ratio is not significant. The multiple comparisons in this experiment were an outgrowth of the experimental design and theoretical framework. Thus, comparisons were made for each hypothesis. However, in exploratory research such as this great caution should be exercised in their interpretation.

Edwards (1960) and McGuigan (1960) recommend the use of Duncan's multiple range test as a technique to be used for closer inspection of the means once the analysis of variance has yielded the results on the overall F ratios. Duncan's multiple range test provides the ranking order of the means for the different experimental problems and the significant difference. In addition, it was available in program form for operation on the data by the computer and consequently for all of these reasons it was adopted for use in the experimental analysis. Significant differences at the .05 level and above will be reported and a discussion of results will be made on a most conservative basis.

Hays (1965) feels that it is important not to consider the statistical significance of results alone but to carefully observe, record and discuss what appears to be relevant in the experiment and to be a master but not a prisoner of statistical techniques. Consequently in the sections that follow, the results of the analyses of variance and Duncan's multiple range test will be presented. Observations will be made, all the data will be available and any interpretation of the Duncan test must be regarded with the appropriate caution.

Information in this section might serve as a stimulus for further research.

The analyses of variance reveal some low F ratios which might reflect more than merely a lack of significant difference. It could be that some uncontrolled variable was systematically in operation and that the error term reflects an experimental condition involving more than error variance. However, these low ratios are still within the probability range of being a result of chance and therefore the hypotheses may be considered in terms of these results. The suggestion of a possible extraneous variable being in operation is raised only as a source of future and, perhaps fruitful, research. This will be discussed later.

A summary of each analysis of variance and a summary of the Duncan mulitple range test are presented in Tables 2-6. The cell and marginal means from the analysis of variance appear in Appendix C. The section for each hypothesis involving the main effects contains a summary table of the marginal means of the appropriate factor under examination. The Duncan new multiple range test was used to determine the significant difference between these means.

In sections that follow, each hypothesis is examined in terms of these results. Each main effect and each interaction, which form the bases for the hypotheses, will be examined in terms of the four dependent variables which the computer program has labeled as Problem 1 through 4. The computer labeled these problems as follows and these labels will be used in the tables of results and in the discussion: Problem 1: knots; Problem 2: tests; Problem 3: practice step; Problem 4: test step.

The results of the analysis will not prove or disprove the hypotheses. Actually, the statistical evidence will either be in favor of the hypotheses or not and within the specified level of probability. This is what will be meant in the sections that follow when the hypotheses are confirmed or not confirmed.

TABLE 2. SUMMARY OF THE ANALYSIS OF VARIANCE. PROBLEM 1: KNOTS

Source of variation	Degrees of freedom	Sums of squares	Mean squares	F
1	2	318.90000	159.45000	4.86[*]
2	2	20.63333	10.31667	
3	1	0.20000	0.20000	
12	4	16.96667	4.24167	
13	2	54.90000	27.45000	
23	2	13.30000	6.65000	
123	4	16.10000	4.02500	
Within replicates	162	5309.80000	32.77654	
Total	179	5750.80000		

Number of variables 3
Number of replicates 10

Variable	Number of levels
1[*]	3
2	3
3	2

Grand mean 3.13333

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[*] Significant at $p < .01$

[*] 1 = Rate; 2 = massed—spaced; 3 = concurrent—nonconcurrent

TABLE 3. SUMMARY OF THE ANALYSIS OF VARIANCE. PROBLEM 2: TESTS

Source of variation	Degrees of freedom	Sums of squares	Mean squares	F
1	2	294.81111	147.40556	4.80*
2	2	29.01111	14.50556	
3	1	0.13889	0.13889	
12	4	7.48889	1.87222	
13	2	52.14444	26.07222	
23	2	2.54444	1.27222	
123	4	21.22222	5.30556	
Within replicates	162	4968.70000	30.67099	
Total	179	5376.06111		

Number of variables 3
Number of replicates 10

Variable	Number of levels
1	3
2	3
3	2

Grand mean 2.87222

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*Significant at $p < .01$

*1 = Rate; 2 = massed—spaced; 3 = concurrent—nonconcurrent

TABLE 4. SUMMARY OF THE ANALYSIS OF VARIANCE. PROBLEM 3: PRACTICE STEP

Source of variation	Degrees of freedom	Sums of squares	Mean squares	F
1	2	120.03333	60.01667	12.09*·
2	2	28.13333	14.06667	
3	1	86.80556	86.80556	18.67*·
12	4	8.43333	2.10833	
13	2	10.41111	5.20556	
23	2	36.97778	18.48889	3.98*
123	4	30.25556	7.56389	
Within replicates	162	753.50000	4.65123	
Total	179	1074.55000		

Number of variables 3
Number of replicates 10

Variable	Number of levels
$1^{\underline{*}}$	3
2	3
3	2

Grand mean 6.05000

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*Significant at $p < .05$

*·Significant at $p < .01$

$^{\underline{*}}$1 = Rate; 2 = massed—spaced; 3 = concurrent—nonconcurrent

TABLE 5. SUMMARY OF THE ANALYSIS OF VARIANCE. PROBLEM 4: TEST STEP

Source of variation	Degrees of freedom	Sums of squares	Mean squares	F
1	2	83.20000	41.60000	6.87[*·]
2	2	14.70000	7.35000	
3	1	68.45000	68.45000	11.14[*·]
12	4	16.40000	4.10000	
13	2	12.93333	6.46667	
23	2	44.10000	22.05000	3.64[*]
123	4	52.66667	13.16667	
Within replicates	162	980.50000	6.05247	
Total	179	1272.95000		

Numbers of variables	3	Variable	Number of levels
Number of replicates	10	1[±]	3
		2	3
		3	2
		Grand mean	5.85000

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[*] Significant at $p < .05$

[*·] Significant at $p < .01$

[±] 1 = Rate; 2 = massed—spaced; 3 = concurrent—nonconcurrent

TABLE 6. SUMMARY OF THE DUNCAN NEW MULTIPLE RANGE TEST

Treatment means in ranked order and groups of homogeneous subsets*

Problem 1: knots		Problem 2: tests		Problem 3: practice step		Problem 4: test step	
Number	Mean	Number	Mean	Number	Mean	Number	Mean
.01 .05		.01 .05		.01 .05		.01 .05	
18	0.00	18	0.00	18	2.30	18	2.30
16	0.00	16	0.00	16	4.00	16	3.90
15	1.90	17	1.40	6	4.90	13	4.90
9	1.90	14	1.70	13	5.10	6	4.90
14	2.10	15	1.90	14	5.30	8	5.30
17	2.30	9	1.90	12	5.50	12	5.50
13	2.30	13	2.30	8	6.00	14	5.60
7	2.90	11	2.40	15	6.10	15	5.70
11	3.20	7	2.90	4	6.10	10	6.00
10	3.20	10	3.00	17	6.60	9	6.00
6	3.80	3	3.30	10	6.60	4	6.10
12	4.10	6	3.70	9	6.60	5	6.30
3	4.10	12	3.90	11	7.00	11	6.90
8	4.40	8	4.30	5	7.00	1	6.90
2	4.80	2	4.50	3	7.10	7	7.00
5	4.90	5	4.60	7	7.50	17	7.10
1	5.00	1	4.90	2	7,50	3	7.40
4	5.50	4	5.00	1	7.70	2	7.50

*Refer to Table 1 for the number of each experimental group

Rate of Presentation Effect

Hypothesis I states that: The rate of presentation of filmed stimulus materials significantly affects motor performance. The medium rate of presentation will be significantly better than the slowest or the fastest rates.

A summary of the results of the complete analysis is presented in Tables 2-5. The results of the analyses of variance on the four problems in performance support the first part of the hypothesis at the .05 and .01 levels of confidence but within the limits of the selected values of the variable. The rate of presentation of filmed stimulus materials does significantly affect motor performance.

An inspection of the marginal means for rate of presentation in each of the four problems reveals that the means rank in the following descending order in terms of the effectiveness of the level of the treatment: slowest, medium, fastest. The Duncan new multiple range test was used to determine the significant differences between the marginal means. These results are presented in Table 7.

TABLE 7. MARGINAL MEANS FOR RATE OF PRESENTATION IN PROBLEMS 1-4

Levels of A	Problem 1	Problem 2	Problem 3	Problem 4
1 slowest	4.68333	4.33333	6.71667	6.51667
2 medium	3.28333	3.06667	6.53333	6.11667
3 fastest	1.43333	1.21667	4.90000	4.91667
Mean differences				
1-2	1.40	1.27	.18	.40
1-3	3.25$^{\underset{\bullet}{*}}$	3.12$^{\underset{\bullet}{*}}$	1.81$^{\underset{\bullet}{*}}$	1.60$^{\underset{\bullet}{*}}$
2-3	1.85*	2.85$^{\underset{\bullet}{*}}$	1.63$^{\underset{\bullet}{*}}$	1.20$^{\underset{\bullet}{*}}$

*Significant at $p < .05$
$^{\underset{\bullet}{*}}$Significant at $p < .01$

A significant difference at the .01 level was found between the slowest and fastest pairs of marginal means in each of the four problems. A significant difference at the .01 level was found between the medium and fastest pairs of marginal means in Problems 2-4 and at the .05 level in Problem 1. These results give support to half of the second part of Hypothesis 1 within the limits of the selected values of the variable. The medium rate of presentation is significantly better than the fastest rate. However, the slowest rate is also superior to the faster rate at the same level of significance. The medium rate was not significantly better than the slower rate in this investigation and therefore half of the second part of Hypothesis I is not confirmed. The marginal means of the slowest rate ranked highest in all four of the problems although they were not significantly higher than the means for the medium rate.

Further research might yield data that would reveal significant differences between marginal means of the medium and slower rates. The results of the analyses of variance and an examination of the marginal means in this study give strong support to the following conclusions in terms of Hypothesis I but within the limits of the selected values of this variable. Rate of presentation does significantly affect motor performance and the slower rates of presentation are significantly better than the faster rate of presentation.

The Duncan new multiple range test was used to find the significant differences between the means in all four problems. These results are presented in Table 6. Problems 1 and 2 had an insignificant overall F ratio. The Duncan test revealed the presence of one homogeneous subset in both of these problems, thereby indicating that no significant differences existed between the individual means in these two problems.

Problems 3 and 4 which involved step analysis scores had significant overall F ratios which have already been discussed. The Duncan test revealed the presence of five homogeneous subsets at the .05 level and three homogeneous subsets at the .01 level in Problem 3. There were three homogeneous subsets at the .05 and .01 levels in Problem 4. The vertical lines on Table 6 reveal the subsets in each problem and indicate the significant differences between the means. These differences may be pointed out and observations may be made but any interpretation must be made with caution for the reasons discussed earlier in this chapter.

The results of the Duncan test in Problems 1 and 2 may be approached only in very general terms. The results were not significant and any analysis beyond the listing of the rank order of the means should be undertaken with the appropriate caution.

With this warning stated, the results of the Duncan test in the first two problems revealed that the top four ranking means were in the slowest rate of presentation group of treatments. The means of the medium rate treatments were towards the middle ranges and the faster treatment means were all in the lower half of the range.

The results of the Duncan test in Problem 3 revealed significant differences between means at the .01 and .05 levels and those are shown in Table 6. The three lowest means in Problem 3 formed a homogeneous subset at the .01 level and all were in the fastest group of treatments. The mean of the lowest group was significantly lower at the .01 level than all of the means outside of this subset. The six highest ranking means were significantly higher than the lowest ranking mean at the .01 level and four of these were in the slowest group of treatments.

The results of the Duncan test in Problem 4 revealed that the five lowest means were in a homogeneous subset at the .01 level. The lowest three of these means were in the fastest group of treatments. The two other significantly low means in this subset were in the slowest and medium group of treatments. The two highest means were in a homogeneous subset at the .01 level and both of these means were in the slowest group of treatments. Both of these means were significantly better than the two lowest means at the .01 level.

An inspection of the ranking of the means reveals that the higher ranked means tend to be in the slower treatments and the lower means tend to be in the faster treatments. Most of the significant differences at the .01 level are between the slowest and fastest groups of treatments. These results tend to parallel the results of the analysis of variance and marginal means. However, the analyses of variance and marginal means revealed no significant differences between the slowest and medium rates of presentation.

An examination of the number of subjects in each experimental condition who were able to tie the knot correctly revealed that as the rate of presentation decreased, the number of successful subjects increased. The results are presented in Table 8.

In summary, the results of the four analyses of variance and the examination of the marginal means give strong support to the following conclusions in terms of the hypothesis but within the limits of the selected values of the variable. Rate of presentation does significantly affect perceptual motor performance and the slower rates of presentation are significantly better than the faster rate of presentation.

TABLE 8. NUMBER OF SUBJECTS WITH KNOT SCORE IN PROBLEM 1

Rate	A_1* 28	A_2 20	A_3 11
Massed—spaced	B_1* 21	B_2 20	B_3 18
Concurrent—nonconcurrent	C_1* 36	C_2 23	

	A_1	A_2	A_3
B_1	11	7	3
B_2	10	6	4
B_3	7	7	4

	A_1	A_2	A_3
C_1	19	12	9
C_2	13	8	2

	B_1	B_2	B_3
C_1	10	13	13
C_2	11	7	5

*A_1 = Slowest rate; A_2 = medium rate; A_3 = fastest rate

*B_1 = Spaced mode; B_2 = medium massed mode; B_3 = massed mode

*C_1 = Concurrent mode; C_2 = nonconcurrent mode

Massed-Spaced Practice Mode Effect

Hypothesis II states that: The massed and spaced practice modes significantly affect motor performance. The medium massed mode will be significantly better than the spaced or massed mode.

A summary of the results of the complete analysis is presented in Tables 2-5. The results of the analyses of variance on the four problems in performance do not support the hypothesis within the limits of the selected values of this variable. The analyses of variance in Problems 1 and 2 revealed low F ratios and no significant differences for this massed-spaced main effect. Analysis of Problem 3 which involved the step analysis scores for the practice period yielded an F ratio that approached the .05 level but this disappeared if the error term was pooled. The results yielded a low F ratio in Problem 4 where the step analysis test scores were given.

The results of these analyses of variance do not confirm the hypothesis, and judgment should be suspended until further research has been done on this effect. A significant interaction is suggested between the selected values of this variable and those of the concurrent and nonconcurrent practice modes in Problems 3 and 4. If significant interaction is found, conclusions with respect to either of the main effects involved must be interpreted with caution. The effect of selected values of one variable would not be independent of the selected values of the other variable. However, an analysis of the evidence on this possible interaction resulted in the suspension of judgment pending further research. Consequently, the results on this main effect should be approached with appropriate caution.

An inspection of the marginal means for the four problems reveals no significant differences for Problems 1 and 2. The means rank in the following descending order numerically: spaced, massed, medium massed. These results are presented in Table 9.

TABLE 9. MARGINAL MEANS FOR MASSED-SPACED PRACTICE MODES IN PROBLEMS 1-4

Levels of B	Problem 1	Problem 2	Problem 3	Problem 4
1 spaced	3.58333	3.43333	6.51667	6.20000
2 medium	2.76667	2.51667	6.08333	5.85000
3 massed	3.05000	2.66667	5.55000	5.50000
Mean differences				
1-2	.82	.77	.43	.35
1-3	.53	.92	.96	.70
2-3	.29	.15	.53	.30

In Problems 3 and 4 where step analysis scores were given, a different order appears. The means rank in the following descending order numerically: spaced, medium massed, massed. The analyses of variance did not reveal the presence of a significant F ratio at the .05 level in any of the problems in the experiment. However, it is interesting to inspect the ranked order and illustrated relationship of the marginal means of the three massed-spaced practice modes.

In summary, the results from the four analyses of variance do not confirm this hypothesis. A low, insignificant F ratio in three of the problems indicates that there was no main effect for massed-spaced practice modes in this study. An examination of the marginal means in each problem yields no significant differences. The hypothesis was not confirmed on the basis of these experimental findings.

A presentation of the results of the Duncan test for the significant differences between means may be undertaken but even more caution must be exercised in any interpretation because the overall F ratios and marginal mean differences were insignificant.

The general results of the Duncan test for each of the problems has been discussed in the section on the first hypothesis. The results appear in Table 6.

No significant differences were found between the individual means in Problems 1 and 2. The means are scattered throughout the three levels of this variable in Problems 1 and 2 and there is no discernible pattern.

Significant mean differences were found at the .01 level in Problems 3 and 4 but when these differences were examined in terms of this variable, no discernible pattern was found.

An examination of the number of subjects in each experimental condition who were able to tie the knots correctly revealed that as practice became more massed, the number of successful subjects declined. However, the total numbers in each level were so close that they virtually were the same and particularly in this case when the overall F ratios were insignificant. These results are presented in Table 8.

In summary the results of the four analyses of variance and the examination of the marginal means do not confirm the hypothesis.

Concurrent-Nonconcurrent Practice Mode Effect

Hypothesis III states that: The concurrent and nonconcurrent practice modes significantly affect motor performance. The concurrent practice mode will be significantly better than the nonconcurrent mode.

The summary of the results of the complete analyses of variance is presented in Tables 2-5. The results of the analyses of variance on Problems 1 and 2 where the binary scoring system was used for the criterion performance test revealed a low F ratio and no significant difference. The analysis of variance on Problems 3 and 4 where step analysis scores were given yield significant F ratios at the .01 level. The analysis in Problem 4 was based on the step analysis scores given during the criterion test.

On the basis of the results in Problems 1 and 2, the hypothesis is not confirmed. On the basis of the results of Problems 3 and 4 where step analysis scores were given to all subjects, all of the hypothesis is confirmed within the limits of the selected values. Judgment should be suspended pending further research. The scales of measurement used in the four problems must be investigated along with other scales of measurement to determine their influence on revealing significant differences.

A significant interaction is suggested between the massed-spaced practice modes and the concurrent and nonconcurrent practice modes in Problems 3 and 4. If significant interaction is found, conclusions with respect to any of the main effects involved must be interpreted with caution. The effect of selected values of one variable would not be independent of the selected values of the other variable. However, an analysis of the evidence on this possible interaction resulted in suspending judgment pending further research. Consequently, the results on this main effect should be approached with appropriate caution.

The marginal means for the four problems are presented in Table 10.

TABLE 10. MARGINAL MEANS FOR CONCURRENT-NONCONCURRENT PRACTICE MODES IN PROBLEMS 1-4

Levels of C	Problem 1	Problem 2	Problem 3	Problem 4
1. Concurrent	3.16667	2.84444	6.74444	6.46667
2. Nonconcurrent	3.10000	2.90000	5.35556	5.23333
Mean differences				
1-2	.16	.06	1.39	1.23*

*Significant at $p < .01$

There were no significant differences found between the marginal means in Problems 1-3. However, the marginal mean of the concurrent practice mode was significantly higher at the .01 level in Problem 4 where the step analysis scores were given during the criterion test.

A presentation of the results of the Duncan test for the significant differences between means may be undertaken but more than usual caution must be exercised because some of the overall F ratios were insignificant. The results of the Duncan test appear in Table 6.

No significant differences were found between the individual means in Problems 1 and 2. The means are scattered throughout the three levels and no discernible pattern was found. Significant mean differences were found at the .01 level in Problems 3 and 4. The three lowest means in Problems 3 formed a homogeneous subset at the .01 level and all were in the nonconcurrent practice modes. The mean of the lowest group was significantly lower at the .01 level than all of the means outside of this subset. The six highest ranking means were significantly higher than the lowest ranking mean at the .01 level and five of these were in the concurrent practice modes.

The results of the Duncan test in Problem 4 revealed that the five lowest means were in a homogeneous subset at the .01 level. Four of these means were in the nonconcurrent practice modes. The two highest means were in a homogeneous subset at the .01 level. These means were in the concurrent and nonconcurrent practice modes.

A cursory inspection of the ranked order of the means in Problems 3 and 4 reveals that the higher ranked means tend to be in the concurrent practice modes and the lower ranked means tend to be in the nonconcurrent practice modes.

An inspection of the ranked order of the means in the four problems suggests some of the concurrent modes may be effective during the practice period but they drop lower in the rank order during the test when subjects have no visual stimuli to help them perform the task. The two lowest means in all of the problems were in the nonconcurrent mode.

An examination of the number of subjects in each experimental condition who were able to tie the knot correctly revealed that a third more of the successful subjects were in the concurrent practice modes. These results are presented in Table 8.

In summary, on the basis of the results of the four analyses of variance and the examination of the marginal means, the hypothesis is not confirmed. However, significant F ratios found in two out of the four problems give sufficient evidence that judgment should be suspended pending further research.

Rate of Presentation by Massed-Spaced Practice Mode Effect

Hypothesis IV states that: There is no interaction between rate of presentation and massed-spaced practice modes which significantly affects motor performance.

A summary of the results of the complete analysis is presented in Tables 2-5. The analysis of variance yielded insignificant and vary low F ratios in all of the problems. On the basis of these results and within the limits of the selected values of the variables the hypothesis is confirmed. The effect of the selected value of the one variable is independent of the selected values of the other variable. The same differences exist between the means at each level of one variable regardless of the levels of the other variable.

An examination of the cell means in terms of this hypothesis reveals no interactions in Problems 1 and 2. These results are presented in Table 11. However, Problems 3 and 4 reveal the possibility of the slowest rate becoming less effective as the practice mode becomes more massed. These results are within the probability range of occurring just by chance.

TABLE 11. CELL MEANS FOR INTERACTIONS

		Problem 1			Problem 2			Problem 3			Problem 4		
		A_1*	A_2	A_3	A_1	A_2	A_3	A_1	A_2	A_3	A_1	A_2	A_3
B_1*	C_1*	5.0	2.9	2.3	4.9	2.9	2.3	7.7	7.5	5.1	6.9	7.0	4.9
	C_2	4.8	4.4	2.1	4.5	4.3	1.7	7.5	6.0	5.3	7.5	5.3	5.6
B_2	C_1	4.1	1.9	1.9	3.3	1.9	1.9	7.1	6.6	6.1	7.4	6.0	5.7
	C_2	5.5	3.2	0.0	5.0	3.0	0.0	6.1	6.6	4.0	6.1	6.0	3.9
B_3	C_1	4.9	3.2	2.3	4.6	2.4	1.4	7.0	7.0	6.6	6.3	6.9	7.1
	C_2	3.8	4.1	0.0	3.7	3.9	0.0	4.9	5.5	2.3	4.9	5.5	2.3

*A_1 = Slowest rate; A_2 = medium rate; A_3 = fastest rate

*B_1 = Spaced mode; B_2 = medium massed mode; B_3 = massed mode

*C_1 = Concurrent mode; C_2 = nonconcurrent mode

The analyses of variance and marginal mean differences for each of these variables have been presented and analyzed in previous sections. The analysis of variance and marginal means revealed that significant differences existed among the selected rates of presentation. No significant differences appeared to exist among the massed-spaced practice modes. The Duncan test results on the mean differences for each of these variables tended to support these findings.

The results of the Duncan test in terms of possible interactions must be regarded with more than usual caution particularly since the hypotheses of no interaction have been confirmed. No discernible patterns of overall interaction was suggested by the Duncan results which are presented in Table 6. However, a possible relationship between the slower rates and practice modes was suggested.

An examination of the number of subjects in each experimental condition who were able to tie the knot correctly reveals that as rate of presentation increases, the number of successful subjects in each condition decreases in each level of the practice modes. There appear to be inverse relationships between rate and practice mode in the slowest and fastest treatment groups. These results are presented in Table 8.

In summary on the basis of the results of the four analyses of variance and a cautious examination of the described data, the hypothesis is confirmed within the limits of the selected values of each of the variables. However, further research should be conducted on the grounds that the possibility of some interaction was suggested in the examination of the relevant cell means.

Rate of Presentation by Concurrent-Nonconcurrent Practice Mode Effect

Hypothesis V states that: There is no interaction between rate of presentation and concurrent-nonconcurrent practice modes which significantly affects motor performance.

A summary of the complete analysis is presented in Tables 2-5. The analysis of variance yielded insignificant and low F ratios in all of the problems. On the basis of these results and within the limits of the selected values of the variables, the hypothesis is confirmed. The effect of the selected values of the one variable is independent of the selected values of the other variable. The same differences exist between the means at each level of one variable regardless of the levels of the other variable.

The analysis of variance and marginal mean differences for each of these variables have been presented and analyzed in previous sections. The analysis of variance and marginal means revealed that significant differences existed among the selected rates of presentation. The hypothesis concerning significant differences between the concurrent and nonconcurrent practice modes was not confirmed. However, judgment was suspended because some of the evidence suggested that future research might reveal significant differences. The Duncan test for significant differences between individual means tended to support these findings. The marginal means were significantly different in rates of presentation but not in concurrent-nonconcurrent practice modes.

The results of the Duncan test in terms of possible interactions must be regarded with more than usual caution in the face of the confirmed hypothesis of no interaction. An inspection of the results of the Duncan test in Table 6 shows that the means of the concurrent experimental groups rank higher as the rate of presentation decreases. The significant mean differences appear to fall within this generalization. However, this observation must be regarded very cautiously and perhaps could serve as a stimulus for further research into a search for significant interactions.

An examination of the cell means in terms of the variables involved in this hypothesis reveals the possibility of some interaction in Problems 1 and 2 where the binary scoring system was used. No interaction is evident in Problems 3 and 4. Again, this observation may serve as a stimulus for further research but certainly must be regarded with caution in the face of the confirmation of the hypothesis of no interaction. These means are presented in Table 11.

An examination of the number of subjects in each experimental condition who were able to tie the knot correctly reveals that as rate of presentation increased, the number of successful subjects decreased in both concurrent and nonconcurrent practice modes. The inspection also reveals that a third more subjects were successful in the concurrent practice mode at each of the rates of presentation. These results are presented in Table 8.

In summary, on the basis of the results of the four analysis of variance and a cautious examination of the described data, the hypothesis is confirmed within the limits of the selected values of each of the variables. The effect of selected values of the one variable is independent of the selected values of the other variable.

Massed-Spaced Practice Mode by Concurrent-Nonconcurrent Practice Mode Effect

Hypothesis VI states that: There is no interaction between massed-spaced practice modes and concurrent-nonconcurrent practice modes which significantly affects motor performance.

A summary of the complete analysis is presented in Tables 2-5. The analysis of variance yielded insignificant and low F ratios in Problems 1 and 2 which involved the criterion test and binary scoring system. Problems 3 and 4 yielded significant F ratios at the .05 level. Step analysis scores were given in these problems. The significant F ratios vanished when a pooled error term was used.

The analysis of variance and marginal mean differences for each of these variables have been presented and analyzed in previous sections. Significant differences did not appear to exist among massed-spaced practice modes. The hypothesis concerning significant differences between the concurrent and nonconcurrent practice modes was not confirmed. However, judgment was suspended because some of the evidence pointed towards the possibility that further research might reveal significant differences. The marginal means of each of these variables were not significantly different except in Problem 4 where the concurrent mode was superior.

The results of the Duncan test in terms of possible interactions must be regarded with the usual caution and perhaps even more so with the mixed pattern of F ratios occurring in the four problems. An inspection of the results of the Duncan test in Table 6 reveals no discernible patterns in Problems 1 and 2. In Problem 3 and 4 the Duncan results suggest that concurrent practice modes may become more effective as the practice mode becomes more massed. Conversely, the results suggest that the nonconcurrent practice mode may become more effective as the practice mode becomes more spaced. The significant mean differences appear to fall within this generalization. However, this observation must be regarded cautiously and should serve as a stimulus for further research.

An examination of the cell means in Table 11 in terms of the variables involved reveals the possibility of some interaction in Problems 1 and 2 where the binary scoring system was used and where no significant F ratios were found for this interaction. The examination of the cell means in Problems 3 and 4 reveals a pattern of interaction. The nonconcurrent practice mode becomes more effective as the practice becomes more spaced.

An examination of the number of subjects in each experimental condition who were able to tie the knot correctly reveals that as the practice became more massed, an increasing number of subjects in the concurrent mode became more successful. As practice became more spaced, an increasing number of subjects in the nonconcurrent mode became more successful. These results are presented in Table 8.

On the basis of the results of the four analyses of variance and a cautious examination of described data, the hypothesis is not confirmed. Even though the F ratios in Problems 1 and 2 would lead towards an acceptance of the hypothesis, the significant F ratios at the .05 level in Problems 3 and 4 present evidence that interaction may exist. The effects of the selected values of one variable may not be independent of the selected values of the other variable. Judgment should be suspended and further research should be undertaken on the main and interaction effects of these two variables.

Rate of Presentation by Massed-Spaced Practice Mode by Concurrent and Nonconcurrent Practice Mode Effect

Hypothesis VII states that: There is no interaction among rate of presentation, massed-spaced practice modes and concurrent-nonconcurrent practice modes which significantly affects motor performance.

A summary of the complete analysis is presented in Tables 2-5. The analysis of variance yielded significant F ratios in all of the problems. The results of the analyses within the limits of the selected values of the three variables confirm the hypothesis. The interactions of any two of the variables are of the same form for the separate levels of the third variable.

This three-way interaction was not statistically significant. However, it proved interesting to examine the nature of the relationship among these variables in each of the problems. The rate of presentation and concurrent-nonconcurrent interaction was examined separately for each level of the massed-spaced practice modes and also averaged over the levels of the massed-spaced practice modes for each of the problems. The means are presented in Table 11. An examination of the means in each problem suggests the possibility of a higher order three-way interaction being found in future research.

Winer (1962) cautions against making posteriori comparisons and particularly when the overall F ratio is insignificant as it is in all of the problems. It should be stated that the results that are graph-

58

ically represented and suggest the possibility of interaction could have occurred from within the probability range of chance. It does appear important, however, to draw attention to the possibility of interaction being found in future research because the F ratio for the three-way interaction approached the .05 level of significance in Problems 3 and 4. If significant interaction were found, the statements on the main effects of the variables would have to be qualified.

In summary, on the basis of the analyses of variance the hypothesis was confirmed within the limits of the selected values of the three variables.

Finally, an analysis of the data for each problem revealed that the seat position in the laboratory appeared to have no significant effect on performance. The five testing positions were very close together, although separated by styrofoam panels. Perhaps a seating effect might have been found if more subjects had been tested at one time.

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to investigate the effects of various rates of presentation in combination with massed and spaced, concurrent and nonconcurrent practice modes on film-mediated perceptual motor performance. The experimental evidence provides support for the following conclusions that can be made within the limitations of the selected values of the variables, the population that was represented by the sample and the level of significance that was adopted before the experiment began:

1. Decreases in rate of presentation are accompanied by improved perceptual motor performance.
2. The scale of measurement and choice of dependent variable influence the amount of significant differences that appears.
3. Massed-spaced practice modes in and of themselves do not differ significantly but show some evidence of interacting with concurrent and nonconcurrent modes in tests where step analysis scores are given. Judgment on this possible interaction should be suspended pending further significant evidence.
4. There is a significant main effect of concurrent-nonconcurrent practice modes on perceptual motor performance in tests where step analysis scores are given. However, judgment on this main effect should be suspended pending further significant evidence.
5. There are no other significant interactions between or among the variables. Any interactions that are suggested by graphic illustration of mean differences could have arisen by chance. Future suggested research should be conducted to determine whether these interactions exist.

Faster and slower rates of presentation, including stop-motion, should be investigated. These rates should be examined independently and in various combinations. More massed and spaced modes should be investigated independently and in combination with each other. A comparable investigation into combined concurrent-nonconcurrent practice modes should be conducted. An examination of more values of each of the selected variables might yield significant differences among the values both when the values are examined independently and in various combinations. Such an investigation might also reveal significant inter-variable relationships.

Follow-up research could involve the use of the video tape recorder for recording the performance of subjects. These video tapes could be used in various ways. They could be used for later examination and verification of scoring. They could be used analytically after the experiment to compare performance and reveal information not planned beforehand. They could be used in the experiment to investigate the effects of visual feedback on individual performance. They also could be used in the developing research on perception where sensory feedback is distorted and delayed and subsequent effects on performance is evaluated.

Once a body of scientific evidence begins to develop on the behavior of individual subjects, investigation could proceed into the area of the effect of the group on individual performance. This experiment could be repeated without the panels that separated the students from each other. Decoys could be planted in the experimental groups and the effect of their behavior on the group could be studied. For example, a treatment involving established poor conditions of learning could be administered to different groups of specific intelligence, sex, age, dexterity, level of anxiety, etc. A coached decoy could be planted in the group and he would be overtly successful during the experiment. What is the effect on the performance of the other subjects in the group? This procedure could be used with or without the decoy and in the group and individual experiment and yield fruitful results. The experimenter noticed during this investigation that the poor conditions of learning seem to frustrate what appeared to be normally successful subjects. Also, some subjects performed well during the practice period but appeared to break down under the stress of the testing period. This should be examined further in individual and group experiments within this multivariable framework. Who are these subjects that are affected by group factors and conditions of stress? Levels of organismic variables carefully built into the research design can help to provide this valuable information.

This study can serve to generate further research and many related follow-up studies were suggested and described. The development of an integrated body of evidence will lead towards more useful practices in the instructional process involving perceptual motor learning in such diverse areas as the performing arts, special education for the handicapped and athletics. Such research may influence educational practice as well as provide insight into how complex perceptual motor skills are learned and how conditions of learning may influence perception and personality.

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Appendix A

Instructions to Subjects

Tape Cartridge 1. You are going to see a knot being tied and then tested to see if it is correct. If the knot is correct, it will be released when it is placed on the testing device. If it is not correct, it will tangle on the testing device. You will see and then practice the same knot throughout the entire practice period. You will be able to watch the knot being tied and tested first. Then you will have a chance to tie and test the knot yourself. Every watching period is followed by a chance for you to practice tying and testing the knot. You will be given instructions when to watch and when to tie once the film starts. You will view and practice until you hear that your practice period is over. Then you will be given a short test to see how many accurate knots you can tie in a certain length of time.

Before you tie each knot, have the cord lying flat on the table in front of you just as it is now. Then pick it up as the film begins. If your cord is tangled from a previous knot-tying, take another one off the testing device and place it flat on the table ready for use.

You will have the same amount of time to tie your knot as is given for the knot that is tied on the film. Don't go beyond this time. If you haven't finished tying your knot within the time limit, stop and get ready for the next one. When you watch the knot being tied on film, your cord should be on the table and your hands at rest. (tape stops)

Tape Cartridge 2. Watch the finger action very carefully while the knot is being tied. Some of the finger actions are slow--others are quicker--but every finger action is important and the correct knot can be tied only by using all of the finger actions. You must use the specific finger used in the film for each finger action in order to end up with the correct knot. Examine your knot and the film knot often throughout the practice session to see if they are the same. You could be missing or doing incorreetly some of the finger actions and yet not realize it. Also you could be tying an incorrect knot that does release on the testing device but is missing one or more important finger actions. Carefully notice the final pattern of the film knot and your knot throughout your practice period. You should check constantly to see that they are the same. Also notice which hole in the knot is placed over the testing device in order to release the knot. Finally, you may have the correct knot pattern though sometimes it may not be obvious to you. Gently move the fingers to see if the correct pattern and testing hole appear--now get ready for your practice period. Watch the knot and then tie and test your knot according to the instructions that follow. Your practice period will be over when you hear the command to stop. (tape stops)

Tape Cartridge 3. (These instructions vary according to the experimental treatment. The instructions for all treatments are given in the next section of this appendix).

Tape Cartridge 4. Stop! Your practice period is over. Place the loops on the testing device and make sure they aren't tangled. Place one loop flat on the table in front of you ready for your testing period. Now you may relax for a minute before beginning your test. (tape stops)

Please get ready for the test. (tape stops) You are going to be tested on the number of accurate knots you can tie in the next five minutes. Tie as many accurate knots as you can. Only the accurate ones will count. Keep tying until you set the command to stop. If your cord gets tangled, take another loop off the testing device. Place the cord flat on the table in front of you for the first knot only. Don't pick up the cord until you get the command to start. Then you may keep the cord in your hands for all the knots from then on. Remember--tie as many accurate knots as you can in the next five minutes and keep tying until you hear the command to stop.

Before you test each of your knots, hold the finished knot position and call out the word check. We will look at your knot quickly and then ask you to test it on the testing device. Are there any questions? (tape stops) *

Ready--start! (tape stops)

Stop! The test is over. Please don't discuss any part of this experiment with anyone until you have received a copy of the abstract. Thank you for being in the experiment. (tape stops)

* (Insert live comment here) If you have not been getting the knot during the practice period, keep practicing and trying to get the knot and test it during the testing period.

Appendix B

Tape Cartridges for Experimental Treatments

One Concurrent

Watch the film knot being tied and tested. (stop)
Watch the film knot while you tie and test your knot. (stop)
Put your loop on the table. (stop)

One Nonconcurrent

Watch the film knot being tied and tested. (stop)
Now you tie and test your knot. (stop)
Put your loop on the table. (stop)

Three Concurrent

Watch the film knot being tied and tested three times in a row--
Knot 1. (stop) Knot 2. (stop) Knot 3. (stop)
Watch the film knot while you tie and test three knots in a row--
Knot 1. (stop)
Put your loop on the table--tie and test Knot 2. (stop)
Put your loop on the table--tie and test Knot 3. (stop)
Put your loop on the table. (stop)

Three Nonconcurrent

Watch the film knot being tied and tested three times in a row--
Knot 1. (stop) Knot 2. (stop) Knot 3. (stop)
Now you tie and test three knots in a row--Knot 1. (stop)
Put your loop on the table--tie and test Knot 2. (stop)
Put your loop on the table--tie and test Knot 3. (stop)
Put your loop on the table. (stop)

Six Concurrent

Watch the film knot being tied and tested six times in a row--
Knot 1. (stop) Knot 2. (stop) Knot 3. (stop) Knot 4. (stop)
Knot 5. (stop) Knot 6. (stop)
Now watch the film knot while you tie and test your knot six times
in a row--Knot 1. (stop)
Put your loop on the table--tie and test Knot 2. (stop)
Put your loop on the table--tie and test Knot 3. (stop)
Put your loop on the table--tie and test Knot 4. (stop)
Put your loop on the table--tie and test Knot 5. (stop)
Put your loop on the table--tie and test Knot 6. (stop)
Put your loop on the table. (stop)

Six Nonconcurrent

Watch the film knot being tied and tested six times in a row--
Knot 1. (stop) Knot 2. (stop) Knot 3. (stop) Knot 4. (stop)
Knot 5. (stop) Knot 6. (stop)
Now you tie and test six knots in a row--Knot 1. (stop)
Put your loop on the table--tie and test Knot 2. (stop)
Put your loop on the table--tie and test Knot 3. (stop)
Put your loop on the table--tie and test Knot 4. (stop)
Put your loop on the table--tie and test Knot 5. (stop)
Put your loop on the table--tie and test Knot 6. (stop)
Put your loop on the table. (stop)

Appendix C

Cell and Marginal Means from Analyses of Variance

Problem 1: Knots

Cell numbers	Means
1. 1 1 1	5.00000
2. 1 1 2	4.80000
3. 1 2 1	4.10000
4. 1 2 2	5.50000
5. 1 3 1	4.90000
6. 1 3 2	3.80000
7. 2 1 1	2.90000
8. 2 1 2	4.40000
9. 2 2 1	1.90000
10. 2 2 2	3.20000
11. 2 3 1	3.20000
12. 2 3 2	4.10000
13. 3 1 1	2.30000
14. 3 1 2	2.10000
15. 3 2 1	1.90000
16. 3 2 2	0.00000
17. 3 3 1	2.30000
18. 3 3 2	0.00000

Marginal Means

Variables	Categories	Means
1	1	4.68333
	2	3.28333
	3	1.43333
2	1	3.58333
	2	2.76667
	3	3.05000
3	1	3.16667
	2	3.10000

Problem 2: Tests

Cell numbers	Means
1 1 1	4.90000
1 1 2	4.50000
1 2 1	3.30000
1 2 2	5.00000
1 3 1	4.60000
1 3 2	3.70000
2 1 1	2.90000
2 1 2	4.30000
2 2 1	1.90000
2 2 2	3.00000
2 3 1	2.40000
2 3 2	3.90000
3 1 1	2.30000
3 1 2	1.70000
3 2 1	1.90000
3 2 2	0.00000
3 3 1	1.40000
3 3 2	0.00000

Marginal Means

Variables	Categories	Means
1	1	4.33333
	2	3.06667
	3	1.21667
2	1	3.43333
	2	2.51667
	3	2.66667
3	1	2.84444
	2	2.90000

Problem 3: Practice step

Cell numbers		Means
1.	1 1 1	7.70000
2.	1 1 2	7.50000
3.	1 2 1	7.10000
4.	1 2 2	6.10000
5.	1 3 1	7.00000
6.	1 3 2	4.90000
7.	2 1 1	7.50000
8.	2 1 2	6.00000
9.	2 2 1	6.60000
10.	2 2 2	6.60000
11.	2 3 1	7.00000
12.	2 3 2	5.50000
13.	3 1 1	5.10000
14.	3 1 2	5.30000
15.	3 2 1	6.10000
16.	3 2 2	4.00000
17.	3 3 1	6.60000
18.	3 3 2	2.30000

Marginal Means

Variables	Categories	Means
1	1	6.71667
	2	6.53333
	3	4.90000
2	1	6.51667
	2	6.08333
	3	5.55000
3	1	6.74444
	2	5.35556

Problem 4: Test step

Cell numbers	Means
1 1 1	6.90000
1 1 2	7.50000
1 2 1	7.40000
1 2 2	6.10000
1 3 1	6.30000
1 3 2	4.90000
2 1 1	7.00000
2 1 2	5.30000
2 2 1	6.00000
2 2 2	6.00000
2 3 1	6.90000
2 3 2	5.50000
3 1 1	4.90000
3 1 2	5.60000
3 2 1	5.70000
3 2 2	3.90000
3 3 1	7.10000
3 3 2	2.30000

Marginal Means

Variables	Categories	Means
1	1	6.51667
	2	6.11667
	3	4.91667
2	1	6.20000
	2	5.85000
	3	5.50000
3	1	6.46667
	2	5.23333